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A FIFTY-TON ELECTRIC CRANE.

By the English Correspondent of SCIENTIFIC AMERICAN.

ONE of the most interesting features of the equipment to the new graving dock at Southampton, recently completed, for the London & South-Western Railroad is the mammoth electric crane designed for dealing with loads up to 50 tons at a radius of 87 feet. This crane is one of the largest of this class yet constructed, and possesses many interesting details.

The installation has been constructed under the superintendence of Mr. Drummond, the well-known locomotive engineer to the railroad, by Messrs. Stothert & Pitt, of Bath, to whom we are indebted for the accompanying illustrations. The electrical equipment, however, has been supplied by the Allgemeine Elektricitäts-Gesellschaft, of Berlin. The crane is operated by electric power throughout, a separate motor being provided for each individual motion.

The crane runs on a twin rail track with a gage of 25 feet 6 inches between rail centers, laid longitudinally along the wall of the dock, being carried on twenty central flanged steel-tired wheels. The length of the wheel base is 30 feet, the clearance under cross-girders of truck 15 feet, and the diameter of roller path centers 25 feet 6 inches.

Each axle bearing is provided with two sets of four volute steel springs, fitted on either side of the running wheels, making a total of 160 springs for the twenty wheels. A notable feature of the plant is the special type of driving gear at the ground wheels that has been constructed by Stothert & Pitt. The object of this is to compensate for the play in the springs.

The under truck of the crane is built upon the lines adopted by this firm in the construction of their ordinary titan cranes, being strongly braced in all directions, thereby insuring strength and rigidity. The jib, which is 85 feet in length, is of the double open-lattice braced boom type. There are four main angles to each boom, with cross bracings at the ends and middle. The height of the jib head from the ground, when the crane is working at the maximum radius of 87 feet, is 60 feet, while at the minimum radius of 60 feet the jib head is 103 feet from the ground. At the maximum radius the jib lies at an angle of 22 deg. from the horizontal plane, and when working at the minimum radius the jib is at an angle of 15 deg. from the vertical.

The derricking ropes are twelve-part and 5½ inches in circumference. They are reeved double, two parts leading from the derrick barrel, the latter being grooved right and left hand. The lifting ropes are six-part, and of 4½-inch circumference. These are also reeved double, two parts leading from the lifting barrel which is similarly grooved right and left. All ropes have a factor of safety of eight when dealing with the maximum load.

The crane house is divided into three sections—front, central, and back respectively. The crane is operated from the front cabin, which is elevated so that the engineer has a clear view of the field of operations, and here are ranged all the control and operating levers. In the center cabin are the slewing and traveling gears with their motors, controllers, and resistances, while the rear section contains the lifting and derricking crabs with their motors.

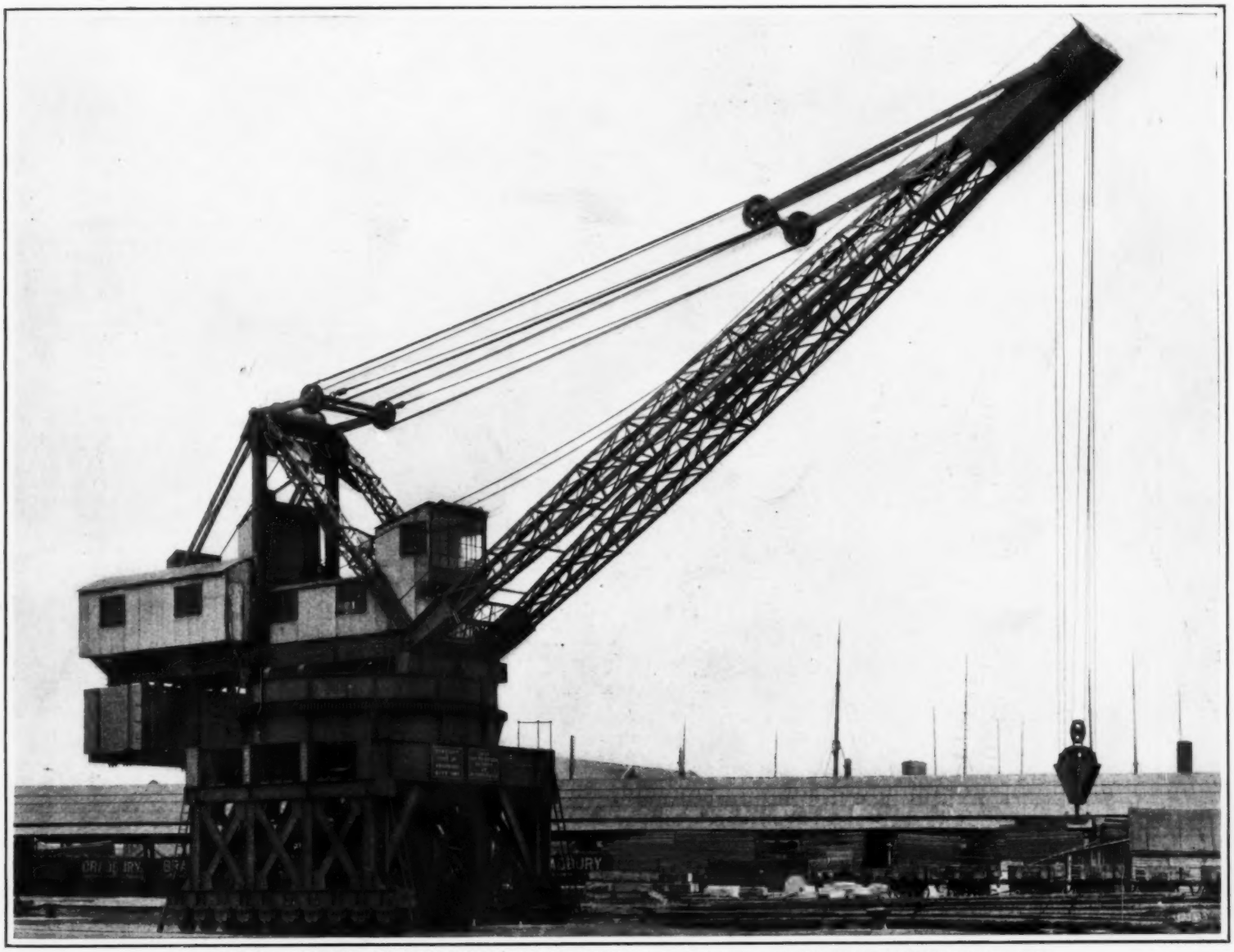
All the various motors run on a 480-volt continuous-current circuit, and are completely inclosed. The lifting motion is carried out by two motors, each of 50 B. H. P. with series-parallel controller. For the derricking motion there is one series motor of 80 B. H. P., a similar motor of 50 B. H. P. for the traveling motion, and one of 25 B. H. P. for the slewing motion.

For the lifting, slewing, and traveling motions machine-cut spur gear is used for all first and second reductions. In the case of the derrick motion, the first reduction is carried out with a worm and wheel, which is inclosed and runs in oil. The necessary current is drawn from ground connection boxes by a flexible cable which is connected to the junction box fitted upon the inside of the crane truck. From the junction box extend cables through the center pin, the top of which is fitted with a collector of the usual type. The current is distributed to each motor and controller from a switchboard placed in the engineer's cabin by a separate circuit.

Solenoid magnetic brakes in series with their respective motors, and connected to their respective controllers, are fitted to both the lifting and derrick gear. A mechanical foot-brake is also provided in addition to the magnetic brakes for lowering the load, while another brake is fitted for checking the slewing motion.

Any tendency on the part of the jib to run out is prevented by equipping the derrick gearing with special frictional plates, which come into action when the radius of the jib is being extended. These friction plates are fitted on the end of the worm spindle, and are operated by a ratchet and pawl. The latter are thrown out of action automatically when the jib is raised.

Beneath the rear cabin is fitted the ballast tank which is of sufficient capacity to carry 70 tons of bal-



A LARGE ELECTRIC CRANE.—LIFTING CAPACITY, 50 TONS AT A MAXIMUM RADIUS OF 87 FEET.

last in concrete blocks. The height of the circular rack from the rail level is 23 feet; while from the rails to the top of the king post the height is 56 feet; and the radius from the center pin to center of tail ballast is 32 feet. The crane weighs 250 tons, or with ballast 320 tons, while with the maximum load the total weight in running order is 375 tons. Although designed for a maximum load of 50 tons the crane has been tested to 70 tons at the full radius of 87 feet.

The track for the crane extends along the east wall of the dock for its full length of 875 feet. The long radius capacity of the crane renders a reach beyond the center line of the dock possible—a useful provision, especially when it is desired to work upon the far side of a docked vessel. It will also prove of great utility for unshipping twin propellers.

RECENT STUDY OF RADIUM.

IN a number of papers recently contributed to the Philosophical Magazine, Prof. Rutherford and others have made further contributions to our knowledge of the properties and life history of radium, which are of great interest, not only to men of science, but to laymen in general, for they carry us forward to such a point that we may be said to have obtained a first glimpse into the very mechanism of creation.

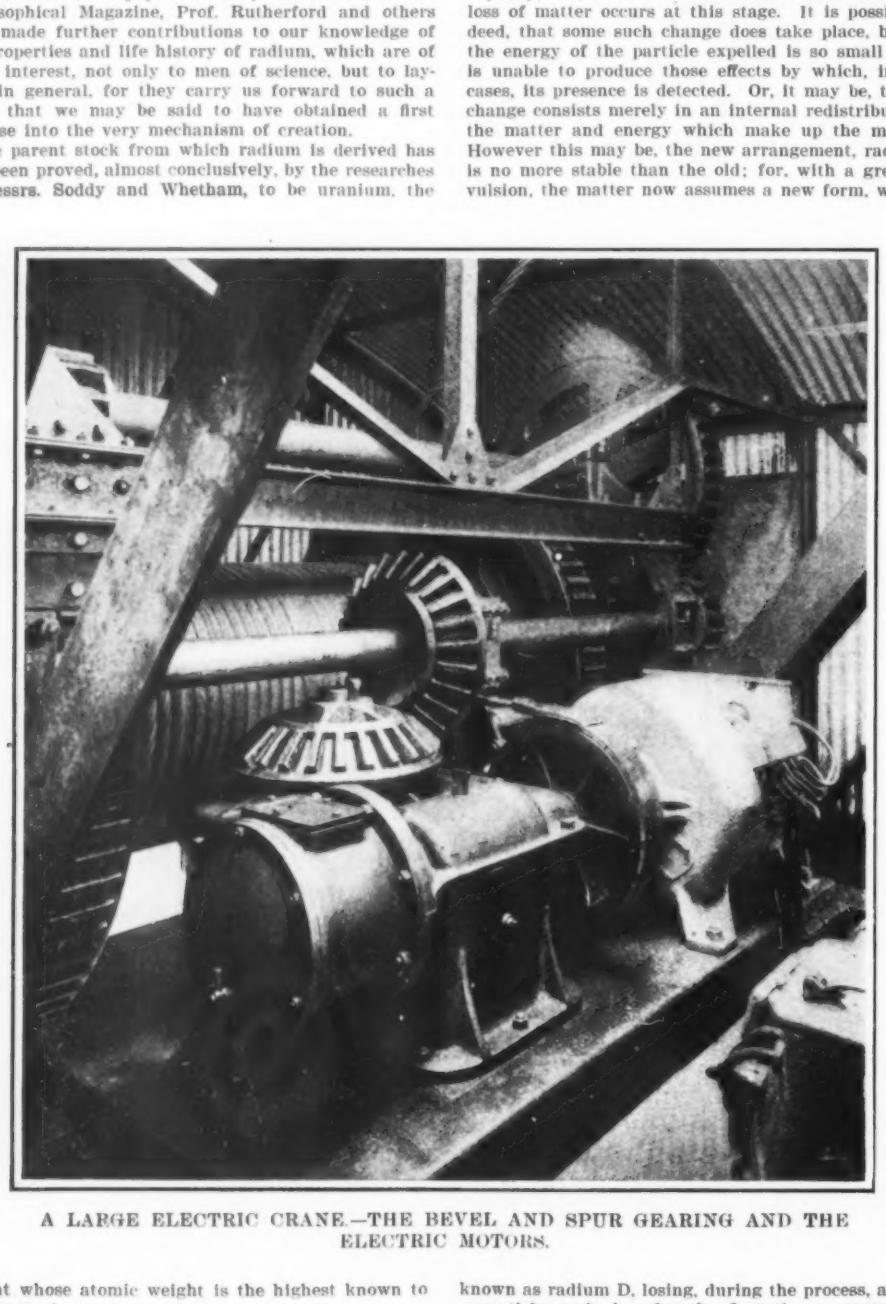
The parent stock from which radium is derived has now been proved, almost conclusively, by the researches of Messrs. Soddy and Whetham, to be uranium, the element whose atomic weight is the highest known to us at present.

Probably on account of their great mass, the atoms of this element are in an unstable condition, the forces which hold together the ultimate particles of which they are composed being almost overpowered by those which tend toward disintegration, and, in process of time, a small proportion of them break up, and form other collocations of matter, one of which has received the name uranium X. But the molecule of this substance, if substance it can be called, is also unstable, and in course of time is, in its turn, replaced by radium. It was at first thought that the change from uranium X to radium was direct. But it has recently been pointed out that, in order to explain certain experiments of Mr. Soddy and Mr. Whetham, it is necessary to suppose that some intermediate product is formed which has not yet been isolated. Radium is thus the lineal descendant of uranium, though the details of the genealogy are still somewhat obscure. But from this point onward the changes undergone by the element have been traced with extraordinary skill and completeness, and no less than seven different transformations of the original atom have been distinguished.

The radium atom, and, indeed, every other atom, probably consists of a whirling mass of particles, some of which are comparatively large, and are charged with positive electricity (α particles), while others are smaller, and carry a negative charge (β particles); and, owing to some cause with which we are not acquainted, but which may be surmised to be centrifugal force, one or more of these particles sometimes escapes from the central mass, and is projected into space with prodigious velocity. It is an astonishing fact that the loss of a single α particle, though its mass is but a small fraction of the total mass of the atom, produces a radical alteration in the properties of the aggregate, changing it from a divalent element, probably solid at the temperature of the atmosphere, into an inert gas, boiling at —150 deg. C. This gas is known as the radium emanation. But the new form of matter is still more unstable than that from which it was derived; and, after a brief struggle against the forces of disintegration, another α particle contrives to escape, and the residue takes the form which is known as radium A. This, in its turn, almost instantly expels a third particle, and assumes the conformation known as radium B.

The next change is accomplished with almost equal rapidity, but, so far as has hitherto been observed, no loss of matter occurs at this stage. It is possible, indeed, that some such change does take place, but that the energy of the particle expelled is so small that it is unable to produce those effects by which, in other cases, its presence is detected. Or, it may be, that the change consists merely in an internal redistribution of the matter and energy which make up the molecule. However this may be, the new arrangement, radium C, is no more stable than the old; for, with a great convulsion, the matter now assumes a new form, which is known as radium D, losing, during the process, another α particle, and also, for the first time, a negatively-charged mass.

This completes what is called the period of rapid transformation, and the next three changes are more deliberate. By a second "rayless" change, which proceeds so slowly that one-half the molecules of radium D are affected in a period of forty years, it passes into a new form—radium E—which, again, by the loss of a β particle, finally becomes radium F. Beyond this point no further action has yet been traced; but, in his most recent paper, Prof. Rutherford suggests that the ultimate product of these successive changes may be identical with the element lead, which is usually found in uranium ores in conjunction with radium, and in quantities such as might be expected on this hypothesis. These extraordinary results might well have appeared to mark the climax of human ingenuity and endeavor in an investigation so difficult and refined. Yet, in reality, they form only the starting point for a new series of researches, leading to results of a still more recondite nature. It has been stated above that the α particle, when it leaves the parent atom, is traveling with a prodigious velocity, estimated to be of the order of 1,000 kilometers a second; and, in the case of radium in radioactive equilibrium, the knowledge we possessed till recently seemed to point to the belief that the initial velocity of these particles varied within certain limits.



A LARGE ELECTRIC CRANE.—THE BEVEL AND SPUR GEARING AND THE ELECTRIC MOTORS.

But, by an investigation of extraordinary delicacy and charm, it has now been shown by Prof. W. H. Bragg, of the University of Adelaide, and Mr. R. Kleeman that the apparent variability in the velocity of the projectiles is due to the confusion of a number of different, though similar, phenomena. Radium, when in radioactive equilibrium, contains, in addition to the original form of matter, the various products of its disintegration, which are known as the emanation, and radium A, B, and C. Each of these forms of matter is continually discharging projectiles, and it is now found that each set of particles is projected with a different velocity, which is approximately constant for the same set. Those which proceed from radium itself are found to move most slowly, and the velocity of projection increases as the disintegration proceeds, till, in the form radium C, the α particle is discharged with a velocity which exceeds that of the α particle from radium by as much as 18 per cent.

It was to be expected that particles of matter, moving with so high a velocity, would impinge with tremendous effect on anything with which they came in contact, and this is found to be the case. In passing through a gas the α particle comes into collision with such of the molecules of which it is composed as come in the line of its flight, and, by the force of its impact, literally dashes them to pieces. So enormous is the initial energy of the projectile that it is capable of destroying about 100,000 molecules before its velocity is reduced by 40 per cent by the resistance it encounters. At this point its power to break up (or ionize) the molecules of the gas falls off with great rapidity, and it is inferred that below this velocity the energy of the particle is not sufficient to break up a molecule of a gas. From these considerations Prof. Rutherford has calculated that the energy required to produce an ion is 2.7×10^{-11} ergs, which is equivalent to the energy acquired by an ion moving freely between two points whose potential difference is 24 volts.

The range of the α particles must vary with their initial velocity, and can be measured by observing the distance from the point of origin at which a gas ceases to be ionized by their bombardment. Now, Prof. Rutherford has recently shown that, as a first approximation, the phosphorescent and photographic actions of the α particles cease at about the same range as the ionizing power, and he concludes that these three properties of the α ray must be ascribed to a common cause. It follows that the photographic action is caused by the ionization of the salts on the plate, and that, in the case of phosphorescence, such as the scintillations well known in the spinthariscope of Sir W. Crookes, the light is produced by the recombination of ions which are formed by the impact of the α rays on the crystalline mass, and not to the fracture of the crystals. It cannot be said, however, that this point is definitely settled, since so high an authority as M. Becquerel does not accept this interpretation of the experiments.

Among the many points of interest which these experiments touch, it will be sufficient to mention one of the most important. Hitherto we have not been in possession of much evidence to show whether the laws of dynamics which apply to molecular masses could also be applied to the movements of atoms and molecules. When Newton extended the laws which govern the movement of masses at the earth's surface to the mutual attractions of the sun and planets, a great generalization was reached. When the observation of the movements of the double stars had proved that the sway of gravitation extended to the uttermost confines of space, a further step had been taken in our knowledge of the uniformity of natural law. But these laws concerned only comparatively large masses, and it still remained to be shown that in the sphere of the infinitely small, as well as in that of the infinitely large, the same laws hold good.

It would be going too far to assert that this question has now been completely resolved. But a flood of light has certainly been thrown upon it by the behavior of radium and its congeners; and the general effect is to increase our conviction that in the small, as in the great, the same order prevails. The α particles, whose mass is as small, compared with the atom, as the atom is in comparsion with objects which are within the sphere of our senses, are found to behave almost exactly as if they were tangible masses. Projected with an initial velocity, they move in straight lines, in accordance with the first law of motion, unless deflected by impressed forces; and, under this condition, they are constrained to move in orbits whose radius of curvature can be calculated by the same formulas as can be applied to the motions of the heavenly bodies. They lose energy on penetrating an atom at a rate which is proportional to the square root of the atomic weight; and, when finally stopped, their energy is transformed into heat, exactly as a hammer is heated by striking an anvil.

It is impossible to praise too highly the series of researches which have led to these results. Scarcely nine years have elapsed since the first clue was obtained which has led to the discovery of radium, and during the early years of the investigation progress was, of couse, extremely slow. The behavior of the new body was so extraordinary that the adjustment of its place in Nature could only be attained at the cost of a reconsideration and partial reconstruction of some of the most fundamental conceptions which had hitherto been accepted in chemistry and physics. Add to this that the quantity of radium available for research purposes is so small that few indeed are the fortunate possessors of a hundred milligrammes, a quantity about equal to one five-thousandth of a pound. Yet, in spite of these difficulties, the accumulation of knowledge has

proceeded with a rapidity and certainty which command the highest admiration among those who are qualified to judge, and constitutes one of the most brilliant achievements in the history of scientific research. —Engineering.

PLATINUM AND PLATINUM ALLOYS.

PLATINUM has won for itself such an important position in jewelry work, etc., during the last few years, that it will not be uninteresting to give some attention to this metal. Platinum has a special claim on our notice, since it possesses this great advantage over all other precious metals, that it has not to go through any process of oxidation or alteration. It therefore enjoys a high reputation in the manufacture of jewelry at the present time, and is specially adapted for replacing silver in white jewelry work. At an earlier period, before it had become possible to bring platinum on the market in such a white condition as is possible now, no one imagined that the metal would one day play such an important part in the manufacture of jewelry; chemistry has, however, been victorious in this respect also; and while platinum-silver was formerly extensively employed, the leading platinum smelting works now also turn out the pure white platinum alloys, which have come into great favor in the higher class of jewelry work.

Platinum is found in the so-called "platinum ore" on the eastern slope of the Ural Mountains, in Brazil, California, Australia, and the East Indies; it is seldom met with in a pure state. It is usually combined with other metals, such as palladium, rhodium, osmium, iridium, or ruthenium; for this reason, these metals have received the name of platinum metals. Like gold, it is frequently obtained by washing from sand containing platinum, 1,000 kilogrammes of sand often containing no more than from 2 to 5 grammes of platinum. Any gold adhering to the platinum is removed by amalgamation with mercury; the platinum is then dissolved in aqua regia, and when this process is complete it is precipitated with sal-ammoniac. The heated residuum, the so-called "spongy platinum," is fused and cast into bars, and the metal is then ready for the workshop. Whereas an aqua regia composed of 1 part nitric acid (40 per cent) and 2 parts hydrochloric acid (22 per cent) will dissolve gold, a more concentrated aqua regia is necessary to dissolve platinum, 7 parts nitric acid and 5 parts hydrochloric acid being required. The product of solution, platinic chloride or chloro-platinate, is a deliquescent dark red-brown powder soluble in water with reddish yellow color, which turns to a dark brown on being heated. If this platinic chloride is precipitated with sal-ammoniac, it appears at the bottom of the fluid as a lemon-yellow powder, and is again dissolved in cold or boiling water. When the water cools, it is eliminated in the form of octahedral crystals, and when the latter are heated, the spongy platinum already mentioned remains as a residuum. This is the process used for extracting the platinum.

The characteristic properties of platinum displayed in its extraction are also seen in its treatment when worked up. It is unaffected by any acids except highly concentrated aqua regia, while a temperature of about 3,217 deg. Fahr. is necessary for its fusion. It cannot, therefore, be soldered or melted by the processes applied in the case of other precious metals, and oxy-hydrogen gas is generally employed for its fusion. In spite of the peculiarly refractory nature of this metal, its fusion is a rapid and easy matter if performed properly. It is impossible to melt 5 kilogrammes of gold in less than 20 minutes; this length of time is, however, sufficient for melting platinum, and moreover it should be borne in mind that the fusion takes place without the admixture of any foreign substance; also the melting furnace is the simplest imaginable, its dimensions never exceeding 30 x 30 centimeters. Moreover, rolling, hammering, etc., can be performed on it without any auxiliary treatment, such as glowing (red heat), etc. Wires of microscopic size can also be drawn from platinum, measured, not by weight, but by their electrical resistances. The ease with which platinum can be worked is remarkable when we bear in mind its high melting point and its capacity of resistance to acids.

With regard to platinum alloys, these are as numerous as the alloys of other metals which have lately come into vogue in the jewelry industry. Here too chemists have had, and still have, a wide field for experiment, and we may confidently predict that, before long, we shall have coloring and hardening alloys just as we now have green-gold, red-gold, yellow-gold alloys, and with the important result that the melting point of platinum will be lowered as it has been in the case of gold. Hitherto platinum has usually been alloyed with silver in goldsmith's work, 2 parts silver to 1 of platinum being taken to form the favorite "platinum-silver." The object has been to produce an alloy having a white appearance, and which can be polished, and at the same time to lower the melting point. Although chemists have succeeded in giving a white appearance to pure platinum, preference has been given to the last-named alloy, its cost being a point in its favor, since the fancy of the purchasing public has been taken by an article which is new and at the same time scarce. This is not altogether to be regretted, since it will stimulate chemists to make further experiments with this peculiar metal, which, from its power of resistance to atmospheric action, is likely to have a brilliant future.

In addition to the platinum alloys already mentioned, the following are well known:

A mixture of 7 parts platinum with 3 parts iridium. This gives to platinum the hardness of steel, which can be still further increased by taking 4 parts of iridium. An alloy of 9 parts platinum and 1 part of iridium was already used by the French in the manufacture of measuring instruments of great resisting power. Compounds of copper, nickel, cadmium, and wolfram are also used in the construction of parts of watches; the latter acquire considerable hardness without becoming magnetic or rusting like steel. For this purpose a compound of 62.75 parts platinum, 18 parts copper, 1.25 parts cadmium, and 18 parts nickel is much recommended. Very ductile platinum-copper alloys have also been made, e. g., the so-called Cooper gold, consisting of 3 parts platinum and 13 parts copper, which is almost equal to 18-carat gold in regard to color, finish, and ductility. If 4 per cent of platinum is taken, these latter alloys acquire a rose-red color, while a golden-yellow color can be produced by further adding from 1 to 2 per cent (in all 5 to 6 per cent) of platinum. The last-named alloy is extensively used for ornaments, likewise an alloy consisting of 10 parts platinum, 60 parts nickel, and 120 parts brass, or 2 parts platinum, 1 part nickel and silver respectively, 2 parts brass, and 5 parts copper; this also gives a golden-yellow color. For table implements a favorite alloy is composed of 1 part platinum, 100 parts nickel, and 10 parts tin. Articles made of the latter alloy are impervious to atmospheric action, and keep their polish for a long time. Pure white platinum alloys have for some time been used in dental work, and they have also proved serviceable in the jewelry branch; e. g., a mixture of 30 parts platinum, 10 parts gold, and 3 parts silver, or 7 parts platinum, 2 parts gold, and 3 parts silver. The alloys of platinum are already very numerous, their composition varying according to the purposes which they are intended to serve, and it will be the task of the jewelry industry to invent more of these alloys in the near future.

With regard to the soldering of platinum, the most important consideration in the working of this metal, this is performed either with the aid of other metals possessing a lower fusing point than platinum, or by direct welding of the pieces of platinum onto each other. There are many solders in existence, but the main principle to be borne in mind in jewelry work is that the soldering seam should be as little perceptible as possible; the solder, therefore, should have the same color as the alloy. A solder which meets these requirements very satisfactorily is composed of 9 parts gold and 1 part palladium, or 8 parts gold and 2 parts palladium. Platinum possesses the valuable property that it can be welded without any solder; an enormous heat is necessary for this, as the metal parts with its heat very rapidly; for this reason the soldering seam must be exposed to the flame of the oxy-hydrogen blowpipe during the entire process.

An obstacle is met with in the bright-cutting of platinum, since the bright-cut usually gets a polish while the surface remains of a dull gray color. If, however, the graving chisel, previously polished, is dipped into oil of turpentine, a little fat will be added to the platinum, and the result will be a pure black bright-cut. Any odor of turpentine adhering to the metal can be removed by washing.

A description of the various uses of platinum in the manufacture of scientific and medical instruments and apparatus would be beyond the purpose of this article. Owing to its extensive use in art workshops, etc., we have considered it important to call attention to this mysterious metal, leaving to the future the task of discovering fresh fields for its employment, and of explaining various phenomena connected with it at present imperfectly understood.—Translated from the Journal der Goldschmiedekunst.

NEW PRINCIPLES IN AERIAL FLIGHT.*

By Prof. JOHN J. MONTGOMERY, Ph.D., Santa Clara College.

THE problem of aerial navigation, having occupied the minds of men from the earliest ages with so little fruitful result, and being enveloped in a mist of obscurity, has given rise to the wildest theories and speculations; in consequence of which, there prevails to-day the most chaotic condition of opinion relative to the entire subject. Hence it seems advisable, before entering this discussion, to present a few preliminary statements, so that the question may be clearly defined, and the successive steps in investigation and experiment understood.

The flight of birds naturally suggests to everyone the idea of navigating the air, and its various phases seem to indicate the proper line of development. These in their natural order are: rising from the ground, continued flight, and soaring or gliding. Most of those who have experimented have endeavored to follow this order, oblivious to the thought that the whole phenomenon of flight is based upon a set of laws unrecognized in mechanics. Herein lies the error that has caused such confusion of thought and so many discouraging failures. This mistake is not to be wondered at; for the simple easy movements of a bird, rising from the ground and gliding through the air, rob the subject of all suggestion of mystery or difficulty.

Those who have followed this investigation have met obstacle after obstacle, and have been forced back to more humble attempts, and have been compelled to study elements that hardly suggested themselves at the beginning. As a result of this retreat in the face of obstacles, the proper order of study seems to be the reverse of that presented by nature. The reason of this will be apparent when we consider that the air is an untried domain of action, and the first step must be to derive safe support from it, just as in navigation the first essential is to understand and apply the principles of equilibrium of a vessel. This must be the foundation on which all development of a vessel is based, and without which it is folly to consider any questions of steering or propulsion.

If this question of equilibrium of an aeroplane is solved, we may securely launch our apparatus in the air, travel through it, study the various phenomena, and finally obtain a mastery over it.

The recent experiments, which I have performed with aeroplanes, seem to justify the belief that the question of equilibrium is so far solved, as to make it possible to glide through the air in safety, and control the direction of movement at will. Thus a basis of action is afforded, and development becomes possible; while, on the other hand, without a knowledge and appreciation of the laws and principles underlying the various phenomena of flight, there is little hope of advance. In the following discussion I shall attempt to point out the most general principles and laws, with their special application to the simple movements of gliding or soaring. My course of study and experiment has forced me to conclude that flight is based upon unrecognized mechanical principles, arising directly from the impact of elastic bodies; and in its essence is the exchange of momenta between two bodies by the action of an elastic medium.

In presenting this thought it is necessary to call attention to the formulæ relative to the impact of elastic particles. These formulæ, though of long existence and universally known, contain elements which have either been overlooked or slightly noticed, but which are very surprising, and, apparently, against the most elementary mechanical principles. In them we find not only an explanation of the phenomena of flight, but also new suggestions relative to motion and energy.

They are as follows:

$(A + B)\ v = 2\,B\,U + (A - B)\,V.$

$(A + B)\ u = 2\,A\,V - (A - B)\,U.$

Let A and B represent two perfectly elastic bodies, having the respective velocities of V and U, and let v and u represent their velocities after impact. In the present application let us assume that B is at rest and that, therefore, its velocity U is zero.

If we assume that A is the greater in mass and moves toward B, it will, at the instant of impact, give to B a greater velocity than itself possessed. But if it is smaller than B, it will, on striking the latter, impart to it a greater momentum than it (A) had; for it impresses upon B the force of its impact and reaction. This must not be understood as meaning that there is any creation of momentum or motion but that the mass A, at the instant of impact, imparts all its direct momentum, and, owing to the compression of the masses, is driven back and exerts an equivalent reaction. It is more than probable that either or both of these results will be seriously questioned by some, as there appear to be erroneous or incomplete ideas, among even students of science, regarding certain elementary questions of motion and force. This deficiency in knowledge seems to exist, because these questions appear too simple and rudimentary to require serious study. Consequently, deductions are drawn from partial investigation, which are far from being correct.

By applying these formulæ we reach the following conclusions: If two large elastic bodies (A and B) without motion are suspended in space (thus being free to follow any impulse) and a third, but smaller body, between them is given an impulse toward one of the larger (A) it will, at the instant of impact, transmit all its motion to A, and rebounding from it, exert a reaction due to its recoil. And traveling back toward the other large body, B, it will repeat the same process. And thus, the continued rebounding of the smaller body between the two larger ones will gradually give them movements in opposite directions. In other words, they will exchange their momenta. An interesting element in this consideration is that either of the larger bodies may, after a time, have a greater momentum than was given originally to the smaller body. Yet if we take the algebraic sum of the momenta of the three bodies, we find it is always equal to the original impulse.

The three bodies constitute a system, and any motion imparted to one is given to the *system;* and while this may result in opposite movements of the parts, the total movement in the whole system cannot exceed that originally imparted to it. These statements are made because the soaring of a bird has remained a mystery so profound that one of the foremost in scientific investigation has said "it seems to be in defiance of all known laws of nature"; and this is so, because of a too restricted comprehension of the phenomenon presented. Most, if not all, have considered a bird's wings as being surfaces suitably formed and adjusted to receive a pressure from a stream of moving air. While this is true in a certain limited sense, it is very far from being a proper statement of the case.

The phenomenon in its essence is only a development of the problems just stated, viz., the exchange of momenta between two bodies by the action of an elastic medium between them; the wings being of such formation and adjustment as to induce a series of impacts of the adjacent air, between their surface and the surrounding air, in consequence of which the bird and the air receive equal and opposite momenta. And hence we must conceive that the bird is not in itself a complete working device, but only one element of a system; the other elements of the system being the great

*Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

mass of the surrounding air and the moving particles of that adjacent. This will become more manifest, as the various elements of fluid movement are presented.

NATURE OF FLUID PRESSURE, AND SPECIAL QUESTIONS OF ENERGY INVOLVED.

Analysis and experiment show that the pressure of fluids is of two kinds, static and dynamic. The static is that of a gas or liquid pressing upon the sides of a closed chamber, while the dynamic is due to the move-

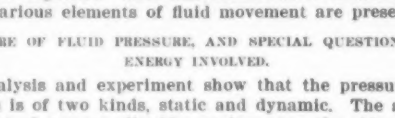


FIG. 1.

ment of fluid particles, and is essentially different from the former in every respect.

The failure to recognize fully the important difference in the nature of these two kinds of pressure is largely responsible for the mystery and confusion of thought relative to flight. In static pressure the problems are of extreme simplicity and are well understood; but in dynamic pressure they are of the most complex and difficult nature, involving questions of elastic impact of moving particles against surfaces, and their impact with and interference by other particles and a return action against the surface, followed by other reactions from the surrounding fluid. In addition to this, there is involved a question of the ap-

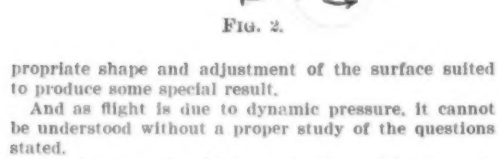


FIG. 2.

propriate shape and adjustment of the surface suited to produce some special result.

And as flight is due to dynamic pressure, it cannot be understood without a proper study of the questions stated.

The elements of a fluid are elastic, and being such, rebound after impact from one another or from a surface. If it were possible to isolate a single fluid particle, it would rebound from other particles of its kind or from surfaces just as a perfectly elastic ball. But owing to the vast number of particles of a fluid, the individual movements are blended into a general resultant, which is expressed or manifested as a stream.

And it is by a study of the movements of these elastic fluid particles that we are led to a knowledge of the

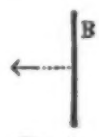


FIG. 3.

mechanics of fluids in motion and the proper form and adjustment of surfaces introduced with a view to produce some special effect. This, applied in the present instance, reveals the secrets of the movements of the air induced by the action of a wing and its proper form and position.

Before entering into a discussion of these movements and their results, I must make some simple suggestions, hoping that the reader may be thereby led into the subject, and thus be able to carry the general idea and see its development in the various principles and experiments presented.

If we hold a square surface, the sides of which are

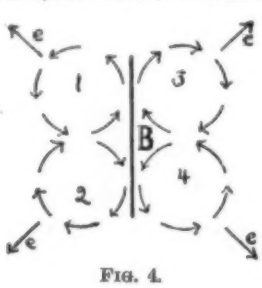


FIG. 4.

equal, in a horizontal position and allow it to drop, it will, in its fall, force the air in equal whirls around its four edges. In this instance the work of gravity is divided between the falling surface and the air escaping around its four edges.

Here the work expended in the air is divided equally in the four whirls; but if the surface be very long and narrow, the work of gravity imparted to the air will be divided between the two whirls around the sides, those at the ends being too small to be considered. If the surface thus descending be given a forward movement, it will cut off some of the escaping air, and thus receive an upward impulse, which is nothing less than the work of gravity the previous instant, returning to the surface; one of the first indications of this return of energy being an increased pressure at the forward edge.

Here we have the first element of the general principle stated in the beginning, viz., the exchange of momenta between two bodies by the vibration of elastic particles. The descending surface striking the adjacent air particles sends them downward, but these meeting the resistance of those below are reflected back and strike the surface.

It may be noted that the suggestion of a long nar-

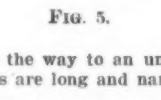


FIG. 5.

row surface paves the way to an understanding as to why a bird's wings are long and narrow.

FLUID MOVEMENTS.

An impulse in a fluid tends to the production of equal and opposite whirls or rotations, which vary in number and development according to circumstances. These may be studied either in air or water, the latter being preferable because of the ease with which the different experiments may be performed. The apparatus most suitable for this purpose is a large flat trough, so arranged that a broad shallow stream may be caused to flow over a flat surface. In the study of single impulses, this extended surface or sheet of water is at rest, but in that of multiple impulses, it flows with a uniform motion and with a velocity that may be regulated, so as to make manifest the various phenomena. When the water is at rest, if a jet of air is forced from a small tube placed near and parallel with the surface, two opposite rotations are produced, as shown in Fig. 1.

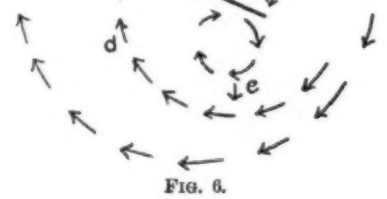


FIG. 6.

These are made manifest by particles of floating chaff, and are due to the reaction of the water at *B* against the impulse. The moving particles always meeting this forward resistance are thrown into the two indicated rotations, and the particles in these rotations, owing to their centrifugal force, press upon the surrounding fluid and tend to drive it away.

Moreover, by their friction they impart their motion to the outside particles, and thus increase the area of rotation. While at the same time the impulse *A* forces the rotations forward, giving them a motion of translation toward *B*.

But if at the point *B* a small flat surface is held in the path of the jet *A*, these two rotations become more pronounced, are held in a fixed position, and by their influence produce two other rotations in the rear of the surface *B*, these in turn giving rise to a current *C*, as illustrated in Fig. 2.

The first point to be noted in this experiment is that

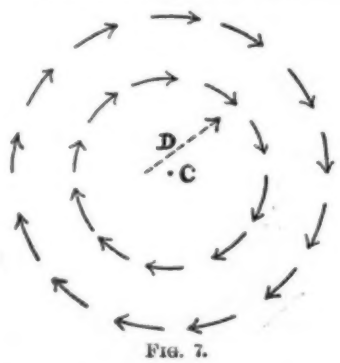


FIG. 7.

a flat surface meeting an impulse normal to itself develops four rotations; and the second is, that the diagonally opposite rotations are in the same direction; i. e., 1 and 4, and 2 and 3.

While these rotations manifest themselves first with a single impulse from the jet *A*, they exist whenever a flat surface is placed on a stream or moved through a fluid.

If the surface *B* is held by the hand and given a gentle movement for a short distance through the water, as shown by the arrow (Fig. 3) and then suddenly stopped, there will appear the four rotations of Fig. 4.

These rotations, at the instant of their formation, move away from one another and from the surface in directions indicated by the small arrows, *E*.

The next step leads us to the all-important phenomenon of fluid movements, and reveals the secret process of gliding or soaring.

If the surface *B*, instead of moving normally against

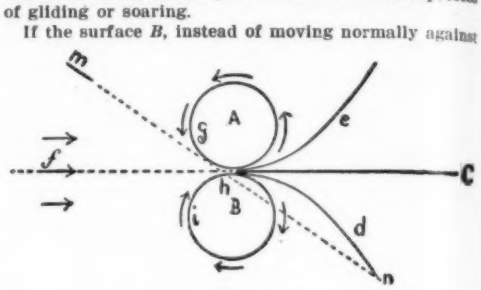


FIG. 8.

the water is held at an angle, as in Fig. 5, and the same operation indicated in Fig. 4 is performed, we shall find that two of the rotations have disappeared and two diagonally opposite remain. These have their rotary movements in the same direction, and are traveling in the directions *e* (Fig. 6).

It is further noted that the fluid around the surface has a general rotation in the same direction as these two; and further, the elements at *d* travel upward against and press upon the forward portion of the surface, while those at *c* move down and against the rear portion of the upper surface.

These varied movements of rotation, being all in the same direction, immediately blend and form one rotation if the plane *b* at the instant of stoppage is lifted from the water; and the final result is a whirl, having a movement of translation indicated by the arrow *D* (Fig. 7).

In these experiments we see that a surface moving at an angle through a fluid builds up a retrograde rotation, the particles rising in front and descending in the rear. This rotation and its elements may not be observed in the elementary test during the movement of the surface, but are detected at the instant the

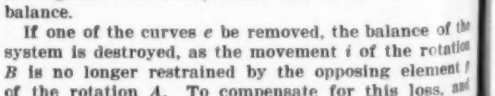


FIG. 9.

movement is checked. Having noted these phenomena, we are directly led to the consideration of the appropriate surface for producing and receiving the impulses of the complete rotation, which we find resulting from the action of a moving inclined plane.

Various lines of thought lead us to this, but the simplest and most direct seems to come from a study of Fig. 1.

Let *A* and *B* (Fig. 8) represent the rotations at any instant shown in Fig. 1. Between these two rotations there is a common tangent line of reaction, *h C*. The circumferences of these rotations and their tangent represent the two extremes of restraint and perfect freedom of movement, and between these there are the curved lines *d* and *e*, representing the line of maximum uniform work. These curves are parabolic, and the points of each are equidistant from the circumferences of the rotations and the tangent *h C*.

These curves represent ideals of actions and reactions intermediate between the movements in a straight line and those of rotation. And their nature is such, that of two surfaces bent to this form and placed as indicated in a stream *f*, the rectilinear movement of the stream would be thrown into the indicated rotary movements, while the surfaces would receive pressures in accordance with the principle, that a par-

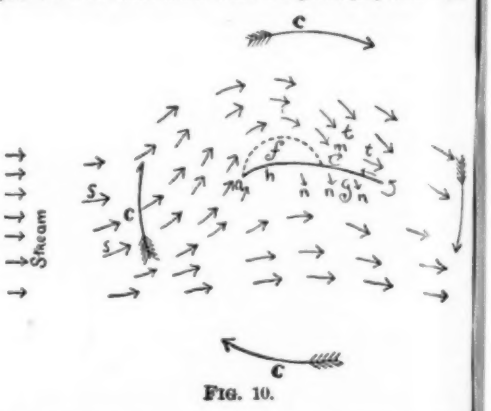


FIG. 10.

ticle deflected from its course should react so as to develop equal work in equal time.

These curves receive all the pressures from the rotations in the directions of the line *h C*, and hold them in a fixed position, the movements *g* and *i* pressing one against the other; hence one holds the other in balance.

If one of the curves *e* be removed, the balance of the system is destroyed, as the movement *i* of the rotation *B* is no longer restrained by the opposing element *f* of the rotation *A*. To compensate for this loss, and produce again the proper movements and pressures within the curve *d*, it is necessary to so place it in relation to the approaching stream, that the missing ele-

ment of pressure *g* may be supplied. This position is found by drawing a tangent from the circumference of *A* to *n*, the rear point of the curve. In this adjustment the stream should approach the curve *d* as if coming from the direction *m* (Fig. 9).

If in accordance with this principle we place the curve *d* in a stream *m*, we have a series of movements beautiful in the extreme, and well calculated to inspire enthusiastic admiration for the phenomena developed in the soaring or gliding of a bird.

To observe these movements, various expedients are resorted to. The bottom on which the water flows (in the apparatus already mentioned) and on which the curved surface rests is covered with sand and fine meal, and light chaff on its surface.

The curved surface being in the indicated position in the stream, the movements of the current, as it approaches, are shown by the arrows *s* (Fig. 10). It reaches the curve in such a direction as to be cut by the point *a*. The portion reaching the under surface produces a decided pressure, greatest at *h*, and is continually thrown off in little darting movements, *n;* while that going above creates a powerful suction at *f*, and, being drawn down toward the curve surface, conflicts with the particles tending to escape around the rear edge. As a result of this, there is a rapid whirl at *m*, and a violent agitation in the region *t t*.

The arrows, *c*, indicate a complete rotary tendency, shown by the chaff floating on the surface. This rotation is perfect under proper conditions, as all the floating particles gather in the region of the curve and continue moving in a slow rotation, while the varied movements mentioned are taking place within the liquid.

Here we have the complete operation of the movements suggested at the beginning, the downward thrust in the rear and the upward return impulse in the front.

Regarding the pressures on the different parts of the curve it may be noted that the effectiveness of the pressure at *h* is very much increased by the suction at *f;* while the effectiveness of that at *g* is greatly diminished by the impact of the descending stream on the rear upper surface.

Owing to these combinations, the total pressure on the curve is located near its front edge; and hence the weight in an aeroplane or wing surface must be located here. This element is most important, as the weight is carried with a minimum forward resistance.

While this is the ideal form and position of the surface, there must be changes in the adjustment of the curves near the center of a bird's wings, in consequence of resistances from the body, and there must be reverse changes in adjustment and slight modification in the form near the tips, in consequence of the escape of air around them. As a result of all these modifications the wings in action have a sinuous form from the center to the tips.

From the points presented in discussing Fig. 10, it may become apparent to the reader, that as each element of cross section i. e., from front to the rear edges, of a bird's wing develops a rotary tendency, there is thus formed a cylinder of rotation, whose axis is below and parallel with the length of the wing, and its direction of rotation is such as to rise in front and descend in the rear. This rotary movement combined with that of translation gives rise to a wave line. And could we see the impulses existing in the air, they would appear as the rotation mentioned in Fig. 10; but were the air made visible by some means, a bird would always appear to be riding in the crest of a wave.

The foregoing discussion, though incomplete, will on consideration show that soaring or gliding flight is not a random affair of a surface dragged through the air, but a definite and peculiar phenomenon of energy and motion. And in it are involved questions not only of fluid movements, but also those of form of surfaces, their position and velocity; all combining to the production of a complete rotary tendency in the air, whereby a special phenomenon of energy becomes manifest.

I can no better illustrate this idea than by reference to the spinning of a top. This simple yet wonderful toy depends for the development of its interesting phenomena on its form, manner of operation, and the rate of its movement. It is an instrument designed for the demonstration of a specific phenomenon, and may fall short of this through deficiency in any of the three elements mentioned.

A further consideration of the fluid phenomena discussed will show that the problem of gliding or soaring is unique in the domain of mechanics. For in all other instances where a body is sustained in its motion, as a ball rolling on a surface, the support given to it is of a positive static nature, while in this the weight is momentarily sustained by the elastic impact of particles, which themselves are set in a downward motion causing a series of actions and reactions, whereby the fluid medium is continually caused to rise in front; thus giving at one instant an upward impulse due to the downward thrust given to the air during the previous instant.

It has been impossible in this article to present all the elements relative to the fluid phenomena mentioned, much less to enter into a full discussion of the principles of energy hinted at in the statements relative to the elastic impact of bodies. These may be presented more fully when occasion demands.

Regarding the aeroplane, I may say that, as this has been already described, repetition is unnecessary. Suffice it to state that, having in mind the various actions and reactions of fluids and surfaces, the formation and relative adjustment of the surfaces necessary for equilibrium and guidance seemed to follow as a logical sequence of the above laws as I understood them. To elaborate the various elements of formation, adjustment, and operation would extend this article to an unreasonable length.

METAL FOUNDRY PATTERNS.*

By WALTER J. MAY.

WHERE large numbers of castings are required from one pattern, the ordinary pine patterns get spoiled with some rapidity, and for this reason metal patterns

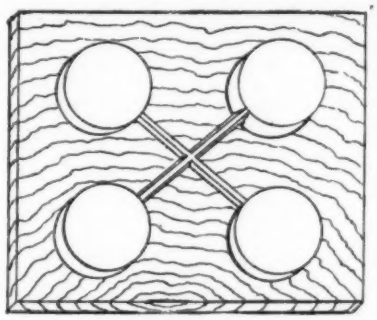


FIG. 1.

become desirable owing to durability. Besides this, the cheapening of production can be secured without reducing wages if some forms of metal patterns are used, larger numbers of castings being turned out with less effort on the part of the molder, owing to the precision with which the molds can be made. Metal patterns are not valueless waste when done

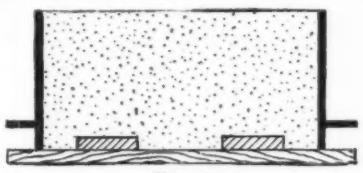


FIG. 2.

with, as with wooden patterns, owing to the fact that the metal value is always present, and with a little care in getting out the patterns the loss is reduced to a small amount indeed. *It is not worth while to make metal patterns unless a considerable number of similar castings are wanted, however.*

Everyone connected with foundry work should, of

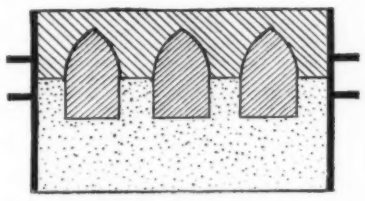


FIG. 3.

course, know that the patterns are first made in wood, and in connection with these it is also necessary to know that two shrinkages plus machining allowances have to be provided for. Thus, if a finished article, such as a turned handwheel, is taken to a foundry as a pattern, the resultant castings will probably be smaller, and no metal for turning off will exist, and

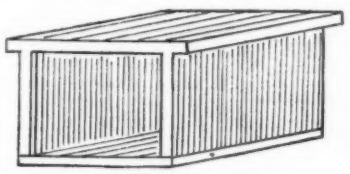


FIG. 4.

however well the molder may "rap out" the pattern, unless he makes a distorted casting, he cannot get it larger than the pattern with which he works. It therefore becomes specially necessary to make such allowances as will be needed in the originating wooden pattern, and this the patternmaker will do, *if he knows for what purpose the patterns are required.* Pine is

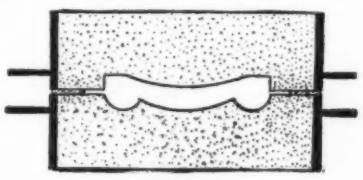


FIG. 5.

quite good enough for these originating patterns, provided it is dry, as possibly only a dozen or so castings will be required in any case. These wooden patterns should be numbered, entered in a reference book, and after use they should be cleaned and stored away.

In regard to the shrinkage of castings, the size of the article has to be considered, as usually the contraction is not equal in all parts, while different metals have different rates of contraction. Thus for iron we may get anywhere between 3-32 inch to 1-16 inch, for brass 5-32 inch to 1-8 inch, and for zinc 5-16 inch, or thereabout; while other metals have their own rates of contraction. Supposing the pattern is to be in brass, and the castings in iron, we should get an allowance for contraction of 3-32 inch plus 5-32 inch, making a total of 1-4 inch to the foot, and if 3-32 inch is to be machined off both pattern and castings we get 3-16 inch added to all parts of the wood pattern, and not merely as a contraction allowance which affects length, breadth, and thickness once only. The pattern-maker

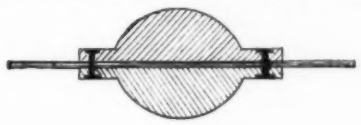


FIG. 6.

understands this, but it is always well to check the measurement of patterns when using them for the preparation of other patterns, as mistakes are often readily made, and will always prove costly.

Without dealing with machine molding, it is quite possible to expedite work in ordinary hand work by having a number of similar patterns in metal; and possibly by using an alloy of 90 parts zinc and 10 parts copper, we get as good a metal for this class of work as can be had, as it is not only cheap and easy to make,

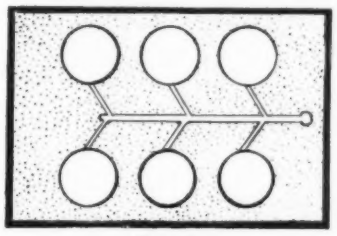


FIG. 7.

but it works well both in melting and machining. Say that we have to make a hundred castings in brass, the pattern being of a circular shape and about 6 inches in diameter. If we have one pattern only, and have no somewhat similar casting to make, each mold will be in a separate flask; and not only the labor, but also

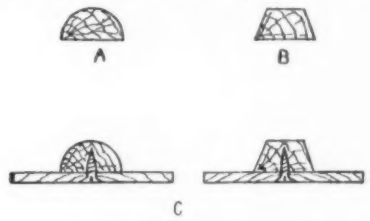


FIG. 8.

will the waste of metal be large. But if we have four patterns arranged as in Fig. 1, we can mold them in about a fourth of the time taken by the single pattern, and shall only have 25 runners instead of 100, which is of importance. Fig. 1 shows the patterns and running arrangement placed on a smooth board, and Fig.

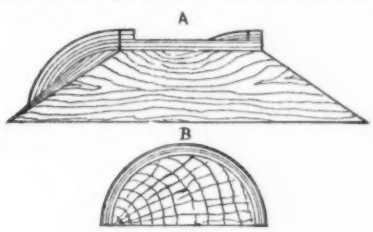


FIG. 9.

2 the drag half of the flask put into position for ramming up. When this half is finished, with the board it is turned over, the surface troweled over and dusted with parting sand, and the cope placed in position and rammed up with a runner stick in the center, and the outside is then finished off. The cope is lifted, the patterns removed, and the molds finished and closed for pouring, the output thus being quadrupled without practically increasing the labor, while the cost of making the four metal patterns is a mere trifle as com-

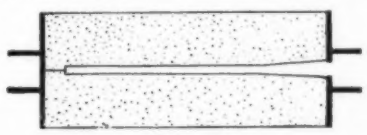


FIG. 10.

pared with the saving in molder's time. In some cases, where thousands of one particular subject are needed, more than four patterns can be worked in one flask; but this is a matter for the person in charge of the foundry.

Where articles of an irregular shape have to be dealt with, and where it is necessary that part of the mold be in the drag and part in the cope, the patterns can still be of metal, but they will have to be let into,

* English Mechanic and World of Science.

or through, the board as far as the joint line, and after the drag has been rammed up and turned over, the board only is removed, the patterns being left in position in the sand. The drag half of the mold is prepared for the reception of the cope in the usual way, the cope being rammed up, and the flask finished in the usual way. This saves considerable time, and with one board and two sets of patterns the output can be nearly doubled if the molders are smart and they will work in pairs. If the molding flasks are made interchangeable, instead of a board, a false cope in plaster can be used, this being made as follows: The metal patterns are very well coated with beeswax in a hot state, and when cold are bedded firmly in their proper positions in the drag half of a flask, and the sand troweled off perfectly smooth. A cope is then fitted on, and the joint made sound outside with clay, after which it is filled with plaster of Paris, worked thin enough to fill well, but it need not be too sloppy. The method of making these false backs is illustrated in Fig. 3, and needs no further description. When the plaster is set hard the cope is lifted, and the sand brushed off the face where it adheres, the patterns taken out, and the plaster back dried. When dry the face of the plaster may be brushed over with some hot beeswax, or perhaps boiled oil, and will be ready for work. The patterns should be a free fit after they are cleaned from the coating of wax, the object being that they shall be left in the sand of the mold when in use. In practice the patterns are placed in the false back, the drag is put on and rammed up, the whole being then turned over, the cope taken off, and an empty one put on and rammed up in the ordinary manner. The saving in labor is considerable with this arrangement, owing to the patterns not having to be bedded in sand; but unless a fairly large number of similar castings are to be made, the cost of preparing the false back can scarcely be justified, while unless the parts of the flasks are interchangeable, a large number of false backs would have to be made. For this latter reason all flasks of similar size should be made so that the parts are interchangeable, this effecting considerable saving in the course of time, while there is but little extra trouble in arranging for this.

Single metal patterns of any sort are made as ordinary castings, but with movable parts where necessary, and after allowing for shrinkage and loss by machining, which leaves them larger than the actual finished castings for which they act as patterns, when put together they are permanent replicas of what the cast articles made from them are to be. This renders metal patterns very useful for articles which have to be made in moderate numbers from time to time, and in which change of design is not likely to take place. At the same time such patterns are heavy, and ample means for rapping and lifting should be provided. Small patterns may be in brass, but large ones should be of some light metal, and an alloy of aluminium 75 per cent and zinc 25 per cent will give a strong metal of less than half the weight of brass, its specific gravity being only 3.4 or 3.5 according to the class of metal originally used. Of course, such an alloy is somewhat expensive, running up to about 1s. 6d. per pound, but for permanent castings for patterns to last a lifetime this is not great, as, bulk for bulk, the castings are not dearer than brass, while, being harder, they are less liable to damage. Where possible, cast patterns should be cored out, and large patterns may be made in two pieces, afterward screwing together, as shown in the section in Fig. 4, where, provided a sufficient thickness of metal is kept to insure rigidity, the hollow patterns are better than solid ones. In fact, patterns in metal can often be built up, partly in wrought and partly cast metal, with advantage, owing to the lightness thus secured; but necessarily it takes time to do this. Most molders prefer light metal patterns if they are well made, as they leave the sand better than wooden ones, and this tends to quicker and better work, which is an advantage.

Where large numbers of any article are being made it often pays to have the patterns worked up on plates, half the pattern on one side and half on the other, the runner being also on the plate, so that all that is needed is to ram up the boxes, and after removing the plate to have the mold complete, while if well made, the plate leaves the molds practically ready for pouring. There are two ways of casting this kind of pattern: either on the plate as one piece with the plate, or as separate patterns to be soldered or screwed on to a separately cast plate. The latter is the preferable way, owing to avoidance of warping, owing to unequal shrinkage, while it allows of an iron plate being used. The patterns are also more readily finished; but they have to be split after finishing, which is not at all times convenient. Where the plate and patterns are cast together, there is, however, considerable trouble in the finishing of the patterns at times, and the question of making plate patterns will have to depend on the conveniences at hand.

In making an ordinary cast pattern-plate, a flask much larger than the plate is taken, and on this the patterns and runners or sprues are arranged, as they will be in the future plate, and the two halves of the box are molded and finished in the usual way, being careful to keep the joint level. When this has been done and the patterns removed, a board of the size of the plate plus shrinkage is laid on the drag, a metal block of the same thickness as the board being placed at the corners of the box at the same time, and the parts of the mold not covered by the board are made up firmly and levelly with sand. The board is then removed, the mold examined and made good where necessary, the cope put in position and weighted down, and the mold poured and the resultant casting allowed to get cold in the mold. The mold for such a pattern plate is shown in section in Fig. 5, and is self-explanatory. After casting, the plate should have holes drilled for the flask-pins to pass through, and any finishing which is necessary should be done, and finally the whole plate should be coated with shellac varnish.

With the other method of working up plates, a cast-iron plate of sufficient size is made and planed on both sides, leaving it, say, ¼ inch in thickness or a trifle more, the size of the plate deciding the thickness. Holes are made for the flask-pins to pass through freely, and then the patterns are arranged in the positions they are to occupy and fixed in position. Personally, the writer prefers to have two holes right through the two halves of the pattern, and corresponding holes through the plate, screwing the whole together as shown in Fig. 6. If the screws are the same shape as those used to hold saw-blades into their handles, so much the better; but this cannot always be arranged, and the patterns will have to be tapped for part of the length of the screws. Where brass patterns are used the ends of the screws can be leveled up with solder, and the same applies with iron; but with zinc or aluminium-zinc patterns the screws should be of brass, with the heads and ends tinned, and the holes over them should be filled with tin. In some cases the patterns are soldered on the plates; but this often leads to false alinement of the molds unless a very careful man does the work, while it necessitates the use of brass plates practically. Individual practice will, however, determine the method of making the plates; but so long as the two halves of the patterns coincide, and the plates are stiff enough for the purpose intended, that is all that is needed. The runners or sprues should be fixed to the plate, and will appear as in Fig. 7, when the pouring is done at the end of the flask. Either half-round or somewhat triangular runners should be used, as shown in section in Fig. 8, the method of fixing to the plate being shown at *C*. If well designed these will leave the sand so cleanly that nothing further need be done to them, but if not well designed for leaving the sand they lift badly and cause a lot of time to be wasted.

In use the plate is put over the pins of the flask, and the second part of the flask put on. The drag side is then rammed up and finished, and the box turned over and the cope finished, after which the plate is rapped on all four sides, the cope lifted and cleaned up, then the pattern plate is removed and the drag half of the mold cleaned up, while finally the box is closed, weighted, and poured. With well-made boxes and pattern plates, if ordinarily good molding is done, there should be no "fins" on the castings, and, save the cutting off of sprues, there should be no fettling necessary. Of course, each pattern has to be dealt with according to its form, and different molders do not always follow the same methods in working, but the result is the same in the end, and while this is so, personal ideas as to procedure are not of very great moment, so long as the result proves satisfactory in regard to cost.

Where large numbers of shaft "brasses" have to be cast, and there is a set of standard sizes, the patterns should be in aluminium-zinc alloy, properly finished, sufficient patterns of each size being made to fill a flask. Everyone who has had these things to do knows the trouble in cutting out the inside of the molds so that the cope shall lift properly; but this difficulty can be got over by having a false metal core made as shown in section in Fig. 9, this core being a replica of the portion of sand lifted with the cope. The pattern and metal core are made a good fit and turned up bright, and are ready for use. In practice a sufficient number of patterns with the cores in place are arranged on a board, a drag is put on and rammed up, and the whole turned over, the face then being troweled off smooth. The cores are then removed, parting-sand is put on, and the cope rammed up in the usual way, being afterward lifted and the patterns taken out and runner and sprues made, the flask being then closed for pouring. With good sand and fair skill in molding, this simple plan will save very considerable time.

Speaking of the molder, care should always be taken that patterns be made in such a way that they give the minimum of trouble to the molder, and whether the pattern be of wood or metal, if part of the casting has to be in the drag and part in the cope, the pattern should be split and doweled so that the part in the cope shall lift with it. This saves an immense amount of time in patching molds, while if the dowels are in that part of the pattern which goes in the cope, the drag can be rammed up on a board with its portion of the pattern in position, and thus save much time and trouble. A few shillings spent in the pattern-shop will save pounds in the foundry, while, quite naturally, greater care is taken of handy patterns than of those which are awkward to the molder. Too often "anything is good enough for the foundry" is the prevailing idea, while much the same occurs with the smithy; but those in charge of works should remember that these two departments originate the work which is to be finished elsewhere, and the better the foundry and smithy turn out the original work, the easier can it be finished.

Where flasks are poured at the end, the runner should be increased in size at that end as shown in Fig. 10; but when poured from the top this is not essential, although for convenience it is often the case, as a tapering runner stick is more easily removed than one which is cylindrical.

The metal of which patterns are made varies very much, according to the ideas of the users; but for preference it should be hard and light. Brass, probably, is more used than anything; but it is very heavy where large patterns are concerned. Possibly the alloy previously mentioned is as good as anything, the cost not coming to much more than brass, even if it costs as much, the bulk being so much greater than that of brass in accordance with weight. The specific gravity of cast iron is about 7.5, of brass about 8.1, gun metal about 8.6, zinc about 6.9, aluminium-zinc alloy 3.5, and pine 0.55, which affords some small assistance in deciding of what metal patterns shall be made; but even with the lightest metal, unless the patterns are made hollow, they must be made much heavier than wood.

Where it is desired to do without machining on metal castings for patterns, if extremely fine sand is used for facing the molds, great smoothness can be secured, especially if the molds are dusted through a fine cloth with plumbago or steatite and properly sleeked; but this, while providing a smooth surface, does not in any way affect the alterations in shape due to contraction, this often being very uneven, owing to the different thicknesses of metal which may occur in one casting. Of course, it is known by most persons who have to do with metal-casting that some shapes will not cast successfully, while there is no difficulty with others, and this has a large bearing on casting patterns, which it is desirable shall be finished when cast, and which it is not desirable to turn or otherwise machine.

With patterns for ornamental work the face cannot be too smooth and fine as a matter of course, it being the general thing to machine and chase the surface of the metal patterns. Besides this the molds made from such patterns should be faced with very fine sand, carefully prepared for the purpose. In fact, many very excellent ornamental castings are spoiled simply because the facing-sand is not properly got ready, and especially with iron the face of an ornamental casting either makes or mars its appearance.

The sand-blast can often be used in preparing both patterns and finished castings; but this is not available at all places, even large foundries often being without this useful apparatus; but it must be remembered that when properly used there is nothing better for cleaning up castings which are to be left as they come from the molds. At the same time, the sand-blast will not do away with the results of bad molding or poor materials, neither will it remove the marks of bad fettling; to procure good castings everything has to be good from a working point of view.

Well-made metal patterns in the hands of good molders produce an almost unlimited number of molds having the minimum of variation, and with good materials produce the best castings at the lowest cost for labor.

CURIOUS OPTICAL ILLUSIONS.*

By ARTHUR K. BARTLETT.

THE lunar halo, which by many persons is regarded as a remarkable and unexplained luminosity associated with the moon, is to meteorological students neither a mysterious nor an anomalous occurrence. It has been frequently observed, and for many years thoroughly understood, and at the present time admits of an easy scientific explanation. It is an atmospheric exhibition due to the refraction and dispersion of the moon's light through very minute ice-crystals floating at great elevations above the earth, and is explained by the science of meteorology, to which it properly belongs; for it is not of cosmical origin, and in no way pertains to astronomy, as most persons suppose, except as it depends upon the moon, whose light, passing through the atmosphere, produces the luminous halo, which, as will be seen, is simply an optical illusion, originating, not in the vicinity of the moon—240,000 miles away—but just above the earth's surface, and within the aqueous envelope that surrounds it on all sides.

A lunar halo, or circles of prismatic colors, seen around the moon, never occurs except when the sky is somewhat hazy, and presents a dull, leaden appearance. Usually only one circle is seen surrounding the moon, and it is always of large size, being about 45 degrees in diameter, or 80 times the apparent diameter of the moon, corresponding to one-half the distance from the zenith to the horizon. The sky within the circle is always apparently much darker than it is for some distance on the outside—a feature which is the peculiar characteristic of a halo when seen under the most favorable conditions—and the circle exhibits the seven prismatic colors seen in the rainbow, and the inner edge being red and quite sharply defined, while the other colors are more or less mingled and superposed, so that the outer edge of the circle is nearly white, and usually not very clearly defined.

Sometimes a number of large circles are seen around the moon, presenting a peculiar and very complicated appearance, and they are seldom concentric as in a lunar corona, but intersect each other with mathematical exactness, exhibiting a structure that is often wonderful to behold. A true halo is never produced when the sky is perfectly clear, as a slight haze is essential to its appearance, and the beautiful illusion is visible only under rare and peculiar atmospheric conditions. In connection with the halo, white bands, crosses, or arches are sometimes observed, which also result from the same conditions of the atmosphere at great elevations above the earth.

A halo may form around the sun as well as around the moon, and all the curious features above described are similarly observed; but a halo is most frequently

* From Popular Astronomy.

noticed about the moon for the reason that we are too much dazzled by the sun's light to distinguish faint colors surrounding its disk, and to see them it is necessary to look through smoked glass or view the sun by reflection from the surface of still water, by which means its brilliancy is very much reduced. When a halo is seen around the sun, a white circle passing through the sun and parallel to the horizon is sometimes observed which is known to meteorologists as the "parhelic circle," from the fact that parhelia or mock-suns are frequently noticed in connection with it. These productions, which are commonly called "sun-dogs," are faint images of that luminary, appearing at one, two, or more points in connection with a halo, and at those parts where the circles cross each other, or cut the parhelic circle above mentioned. The number of these mock-suns, or parhelia, visible at the same time is variable; sometimes one or two only are to be seen, at other times four or five, and on some occasions as many as seven have been observed at once. These mock-suns usually appear about the size of the real sun, but not quite so bright, though on rare occasions they are said to rival their parent luminary in brilliancy and splendor.

Such appearances, which are also seen about the moon (known as mock-moons or "moon-dogs") are most frequently observed in the polar regions, but often occur in the more temperate latitudes, and are produced by the extra light concentrating at those points where the circles intersect, there being at such places a double cause of illumination, presenting the singular spectacle of a faint white disk, resembling that of the sun or moon. Parhelia, or mock-suns, are generally red on the side toward the sun, and they sometimes have a prolongation in the form of a tail, several degrees in length, which coincides in direction with that of the parhelic or horizontal circle. A recent writer on the subject says: "Parhelia have been observed frequently both in ancient and modern times. Aristotle records two appearances of these meteors, and Pliny mentions their occurrence at Rome. A double parhelion, which was noticed before the Christian era, is referred to by St. Augustine. Many others have been observed from different points on the Continent. On January 2, 1586, Christopher Rotham saw, at Cassel, before sunrise, an upright column of light of the breadth of the sun's disk. As he rose to view he was preceded and followed by a parhelion, which appeared in contact with his orb, and continued visible for thirty minutes, and then was hidden by a cloud. On February 28, 1551, mock-suns were seen at Antwerp; and on March 17 of the same year a similar phenomenon, with two halos, was witnessed at the same place. Four days after the last-named two parhelia, with three halos, were seen at Magdeburg."

A halo may be produced artificially, and its appearance beautifully illustrated, by crystallizing some salt (such as alum) upon a glass plate, and then looking through the plate at the sun or a bright light, then the luminous circles above described will be observed. The formation of a circle of light around the sun or moon, and the production of the dark circle to which we have referred, may also be illustrated by an interesting imaginary experiment, which is thus described by the late Prof. Loomis, an eminent authority on the subject of atmospheric phenomena: "If we conceive a beam of light to be admitted through a small aperture into a dark room, and to fall upon a large number of ice-prisms having angles of sixty degrees, and occupying every possible position, all the incident rays will be deviated from their first direction, but in no case will the deviation be less than about twenty-two deg. A large number of spectra will be cast upon the opposite wall, but opposite to the aperture through which the light is admitted there will be a circle of twenty-two deg. radius upon which no spectrum can fall, and the red end of each spectrum will be turned toward the center of the circle. If the number of the spectra be sufficiently great, they will together form a circle of twenty-two deg. radius, bordered with the red upon the inside; but beyond the red the different colors will be so superposed as to produce a light nearly white. . . . The circle within the halo is much darker than the space without it, because from no part of this circle can a ray of the sun, refracted by the ice-prisms, reach the eye of the observer."

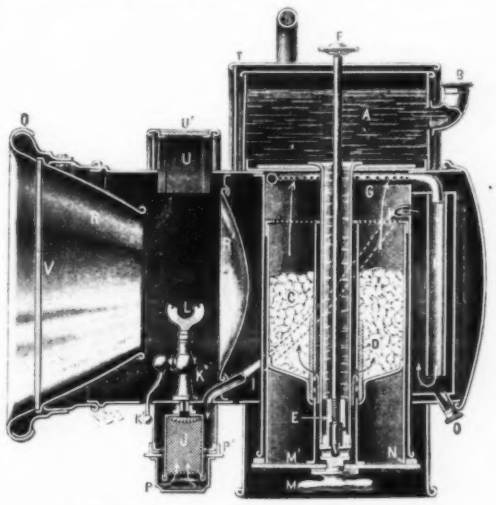
The halo is less brilliant and beautiful, but far more frequent, than the rainbow. Scarcely a week passes during the whole year in which the exhibition does not occur. In summer the ice-crystals that produce the halo are three or four miles high, above the limit of perpetual frost, and for this reason the apparition is sometimes called the "frost-bow." As the rainbow is sometimes seen in dewdrops on the ground, so the "frost-bow" just after sunrise has been noticed in the crystals which fringe the grass. A halo is the bright border of an illuminated zone, and Prof. Olmsted says: "As in the rainbow, so in the halo, the visible band of colors is the only border of a large illuminated space on the sky. The ordinary halo, therefore, is the bright inner border of a zone, which is more than 20 deg. wide. The whole zone, except the inner edge, is too faint to be generally noticed, though it is perceptibly more luminous than the space between the halo and luminary."

A corona is an appearance of faintly-colored rings, often seen around the sun and moon when a light, fleecy cloud passes over them, and should not be mistaken for a halo, which is much larger and more complicated in its structure, as explained above. These two phenomena are frequently confounded by inexperienced observers, but they exhibit peculiar features by which each may be easily distinguished from the other. Both exhibit the seven prismatic colors; but in a corona the colors are reversed, the red being on the outer edge instead of on the inner edge, as in a halo, and the circles of a corona, besides being smaller, are concentric with each other—the inner one being small, the diameter of the second being double, and that of the third treble the diameter of the first. The structure of the corona is quite simple, and never exhibits the attractive features observed in the halo, which is a production of comparatively rare occurrence, while a corona may be seen every time a light transparent cloud comes between us and the sun or moon, and is produced by the diffraction of light passing between the minute globules of condensed vapor in a cloud.

What we have said regarding the size of a halo will alone enable an observer to recognize this phenomenon, and distinguish it from a corona. Prof. Loomis says: "The mean of eighty-three measurements of the radius of the red circle of a halo is 21 deg. 36 min., which is almost identical with the radius computed from theory." The diameter of the luminous circles of a corona is not always the same, and while they are never large, the diameter of the first red ring varies from 3 deg. to 6 deg., and that of the second red ring from 5 deg. to 10 deg.

A corona, like a halo, may be easily produced artificially. If we sprinkle upon a pane of glass a small quantity of lycopodium, or any very fine dust of nearly uniform fineness, and then look at the moon through this glass, we shall see it surrounded by luminous rings of prismatic colors, precisely like those that are formed by a cloud; and if, on a cold winter evening, we breathe upon a pane of glass, the breath will condense into very small globules and freeze. If we look at the moon, or even at a street lamp, through this glass, we shall see a similar system of colored rings, having violet on the inside.

More solar and lunar halos are usually seen in winter than in summer, owing to the favorable conditions of the former season for the formation of ice-crystals in the upper regions of the air for their production, and the singular appearances they present. During the cold weather that prevailed in the winter of 1887-8, the frosty condition of the atmosphere was particularly favorable for the production of these curious displays, and many exhibitions of the kind were observed in various portions of the country where such appearances are uncommon, and have seldom, if ever, occurred before. Many reports of such luminous circles appeared in the newspapers at that time, some of the exhibitions having been unusually interesting and remarkable; but none of the accounts seen by the writer —with one or two exceptions—explained the phenomena correctly, or mentioned their real nature, which was evidently not known or misunderstood by those who described them. On the evening of March 30, 1890, a beautiful lunar halo, accompanied by a "moon-dog," was observed by the writer, and on the following morning a brilliant solar halo with two "sun-dogs," appeared about one hour after sunrise, which attracted great attention from those who were fortunate enough to witness the interesting exhibition.



SECTION OF THE "SALVATOR" SEARCHLIGHT.

A, Water reservoir; *B*, filling tube; *C*, carbide receptacle; *D*, wick; *E*, needle valve; *F*, manipulating screw of needle valve; *D*, gas outlets; *H*, first purifying drier; *I*, conduit for dry gas; *J*, second purifying drier; *K*, burner cock; *K'*, lever of cock *K*; *L*, conjugate burner; *M*, dismounting handle; *M'*, base plate of the carbide receptacle; *N*, rubber joint; *O* drain plug; *P*, plug of purifier; *P'*, joint of the plug; *Q*, door of the lamp; *R*, front reflector; *R'*, back reflector; *S*, handle; *T*, cover for water reservoir; *U*, outlet for burned gas; *U'*, asbestos; *V*, glass of the door.

Of all the numerous weather proverbs current among the people, those relating to the production of a halo should be included with the few for which there is considerable scientific foundation, justified by actual experience and observation. There is perhaps no better known, or more popular, weather prognostic than that pertaining to the lunar halo, which has long been recognized, even among scientific persons, as an almost unfailing sign of foul weather, and reliable indication of an approaching storm. One of the old familiar proverbs relating to the lunar halo is expressed in the lines:

"When round the moon there is a brugh
The weather will be cold and rough."

Prof. John Westwood Oliver, in a recent article on "The Moon and the Weather," published in Longman's Magazine says: "The halo is an old sign of bad weather. Of sixty-one lunar halos observed in the neighborhood of London, thirty-four were followed by rain within twenty-four hours, nineteen by rain within four days, and only eight by no rain at all." As a halo is never seen except when the sky is hazy, it indicates that moisture is accumulating in the atmosphere, which will form clouds, and usually result in a storm. But the popular notion that the number of bright stars visible within the circle indicates the number of days before the storm will occur is without any foundation whatever, and the belief is almost too absurd to be refuted. In whatever part of the sky a lunar halo is seen, one or more bright stars are always sure to be noticed inside the luminous ring, and the number visible depends entirely upon the position of the moon. Moreover, when the sky within the circle is examined with even a small telescope hundreds of stars are visible where only one, or perhaps two or three, were perceived by the naked eye.

A lunar halo, when seen under favorable conditions, with all the curious features that usually accompany it, is one of the most interesting and beautiful exhibitions of Nature; and there are many remarkable facts connected with its formation and appearance that cannot be dealt with in a popular description of the phenomenon, but which are fully explained in nearly every work on natural philosophy, meteorology, or physical geography. In Prof. Loomis's "Treatise on Meteorology" may be found a clear and exhaustive description of halos and coronas, fully illustrated and scientifically explained. There is an instructive popular article entitled "The Lunar Halo," by the late Prof. Proctor, in his admirable work, "Flowers of the Sky," which contains an excellent engraving illustrating the one-ring halo, most commonly observed, and showing the dark space around the moon, which is always noticed in a perfect halo, and is thoroughly explained in the above-mentioned work, together with many other paradoxical features and curious illusions associated with the wonderful atmospheric spectacle.

THE "SALVATOR" ACETYLENE SEARCHLIGHT.

FOR lighting with acetylene, it is advisable to choose calcium carbide generators of the type in which the carbide drops into the water, and the volume of water should be from forty to sixty times greater than that of the carbide. This system is safe, and, with stationary apparatus, gives the best results. In the lamps and searchlights employed for lighting the way of automobiles at night, the use of a drop-carbide generator is out of the question. The vibrations and joltings of the carriage would soon put the organs regulating the discharge of the carbide out of order, and, moreover, it would be necessary to carry quite a large quantity of water, and provide a reservoir for storing the gas, the production of which, in apparatus of this kind, is almost instantaneous, since it is only when the reservoir is nearly empty that the gas is produced anew.

The generators of acetylene lamps may be classed in two types, viz.: Those in which water falls upon the carbide and those with hydrostatic regulator.

In the first, a cock permits of the gradual fall of water upon the carbide, the gas is produced proportionally to the discharge of the liquid, and, when this discharge is not properly regulated, the pressure will rapidly increase if the apparatus is not provided with a relief valve. Consequently, a loss of gas will occur, and the carbide will be poorly utilized. In the second, which operate automatically, the water reservoir is at a level higher than that of the carbide, and a tube leads the water to the base of the receptacle containing the carbide. After the gas is produced, its pressure increases and the water is forced toward the reservoir and does not come into contact with the carbide again until after the pressure diminishes. It is upon this principle that is based the "Salvator" search-light, patented by M. Thezard. The water in the reservoir, *A*, descends through the central tube, passes through the needle valve, *E*, and, ascending, reaches the carbide, *C*, after passing through the wick, *D*. When there is an over-production of acetylene, the water is forced through the wick, *D*. But, since the water is charged with lime, and the wick would soon lose its porosity, the discharge of the water is regulated by means of the needle valve, *E*, in such a way that the quantity of water reaching the wick shall produce with the carbide nearly the volume of gas (from 915 to 1,220 cubic inches) per hour necessary for feeding the conjugate burners of the search-light.

Among other peculiarities of the "Salvator," which is of very strong construction, may be mentioned a double purification of the acetylene at *H* and *J*, which prevents the fouling of the burner tips, and a dismounting handle, *M*, which is used for removing the carbide receptacle. After the latter has been removed, it is possible, if need be, to renew the wick and then examine the operation of the needle valve, or recharge the apparatus.

The operation of the apparatus is very simple. After the reservoir has been filled up to the level of *B*, and the basket has been filled with cracked carbide, the needle valve and then the cock, *K*, is gently opened, and, after all the air has been expelled, the acetylene is ignited and the flame regulated by the lever of the cock, *K*, and by the discharge of the needle valve.

One charge of carbide affords light for about seven and a half hours.

To extinguish the light, the needle valve is first closed and then the cock, *K*, is left open in order that the gas may not accumulate in the generator.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT.

[Concluded from SUPPLEMENT No. 1559, page 24982.]

IRON AND STEEL HULL STEAM VESSELS OF THE UNITED STATES.—VI.*

By J. H. MORRISON, Author of "History of American Steam Navigation."

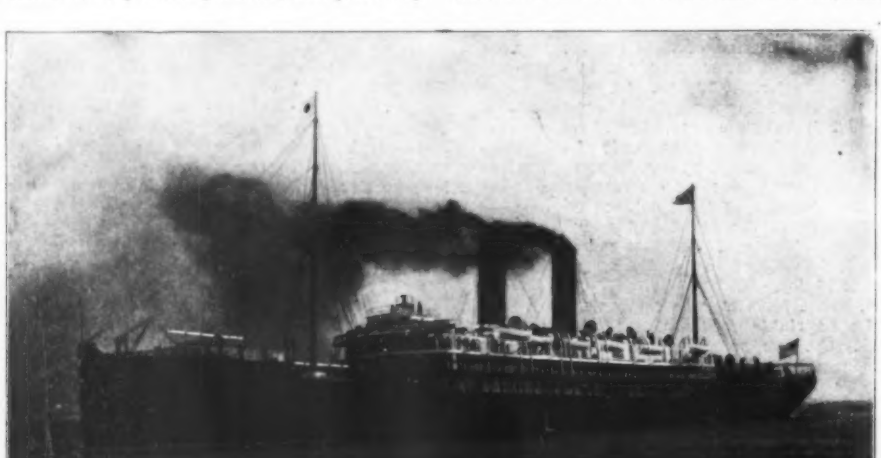
WESTERN RIVERS.

THE building of steel-hull vessels in the Western States, besides those previously named, took place very soon after steel was used for a similar purpose on the northern lakes, by the Iowa Iron Works at Dubuque, Iowa. Their first steel vessel was the sternwheeler "Cherokee," of 220 feet in length, in 1888, followed in two years by the "Ferd. Herold," of 244 feet in length, both having high-pressure engines. The next year they built the snagboat "James B. McPherson" for the U. S. Engineer Corps, of 178 feet in length, and fitted with compound condensing engines. In 1892, 1893, and 1894 they built a number of small river boats, torpedo boat "Ericsson," and revenue cutter "William Windom." In 1899 there were four sternwheel steam tenders for the Mississippi River Commission, of 171 feet in length; and in 1902 the sternwheeler "Sprague," of 276 x 61 x 7 feet 4 inches. This company has built about sixty iron and steel vessels to the present day. There have been some steel hulls constructed lately at Jeffersonville, Ind.

On the Pacific coast the first steel hull was built at the Union Iron Works in 1885 as a propeller, and named "Arago," of 620 tons. Two small vessels were built the next year, and in 1887 the "Premier," of 602 tons, for the Canadian Pacific Railroad Company, was launched by the same company. In the next ten years the same builders had completed, and under construction for the U. S. Navy Department the battleships "Oregon," "Ohio," and "Wisconsin," the monitor "Monterey," the protected cruisers "Olympia" and "San Francisco," gunboats "Marietta" and "Wheeling," and torpedo boat "Farragut."

There was a plant erected in 1895 at Portland, Oregon, by Wolff & Zwicker, who received contracts for building three torpedo boats in the next two years, from the Navy Department.

Iron shipbuilding did not show a steady, increasing growth in the number of vessels built for the first twenty years, that would be expected in a country having the raw material within its boundaries in such quantity as the United States possesses, and the talent and means to convert it into the finished product. During the decade from 1860 to 1870 there were a larger number of iron vessels constructed than there had been built prior to the former date. It was not until 1870 that it can be said that iron shipbuilding in this country began to develop to such proportions as to attract attention, though there were two plants of large size on the Delaware River that were devoted to that industry alone. At this time the fleet of our iron-hull merchant steamers, built in this country, was not imposing in numbers. There were seventeen coastwise steamships that included the "Juniata," "Crescent City," "Mississippi," "Merrimac," "Ellen S. Terry," "Volunteer," "Regulator," 'Champion," "S. R. Spaulding," "Benj. Deford," "Continental," "Havana," "Matanzas," "Gulf Stream," "Benefactor," "Wyanoke," "William Lawrence." There were only two on Lake Erie, the "Merchant" and the "Philadelphia." In the Gulf of Mexico service there were six at New Orleans and two at Mobile, Ala. On the western rivers there was but one, just completed. On the rivers along the Atlantic coast there were about twenty passenger and freight vessels, the larger number of them being in service on the Delaware River. There were also ten or twelve iron steam canalboats, and six new steam colliers, of about 600 tons each, owned by the Philadelphia & Reading Railroad Company. There were a few iron-hull "double-enders," that had been sold by the Navy Department, which were altered, and placed in coastwise freight lines. This shows a total of at least 64 iron-hull steam vessels in service in 1870, that were built in the United States. At this time there were several iron-hull vessels having an American register, or under American enrollment, that were built in Great Britain, that have not been included in the above figures. The four iron steamships built by the Cramp Shipbuilding Company for the American line from Philadelphia to Liverpool, were built a few years later. When it is taken into consideration that in the next decade there were built in the United States 233 iron-hull vessels, it shows how the business of iron shipbuilding had grown in ten years, and nearly one-half of that period the business of the country had been paralyzed from the effects of a financial panic. A large percentage of this increased tonnage was for the coastwise trade. In the next decade, from 1881 to 1890, it is found that there were built 363 steam vessels, some of iron and some of steel; and from 1891 to 1900 there were 530 steam vessels, nearly every vessel being constructed of steel. These figures tell very plainly what the development of our shipbuilding plants has been in ten years even. When we look back to what they were thirty years ago, large enough probably for the surrounding conditions, with the comparatively small plants, and having but few labor-saving tools or machines for the preparation of the material of construction for an iron vessel, it seems almost impossible that such a transformation has taken place in such a short period of time, but the "hustling" methods and ingenuity of the American engineer and mechanic have produced these marvelous results. There will be further advances made in the future, no doubt, in the manner of construction, probably not so radical, or to such a great extent as there have been in the past thirty years or more, but competition of the builders will compel new methods to be adopted so as to reduce the cost of building, if for no other purpose.



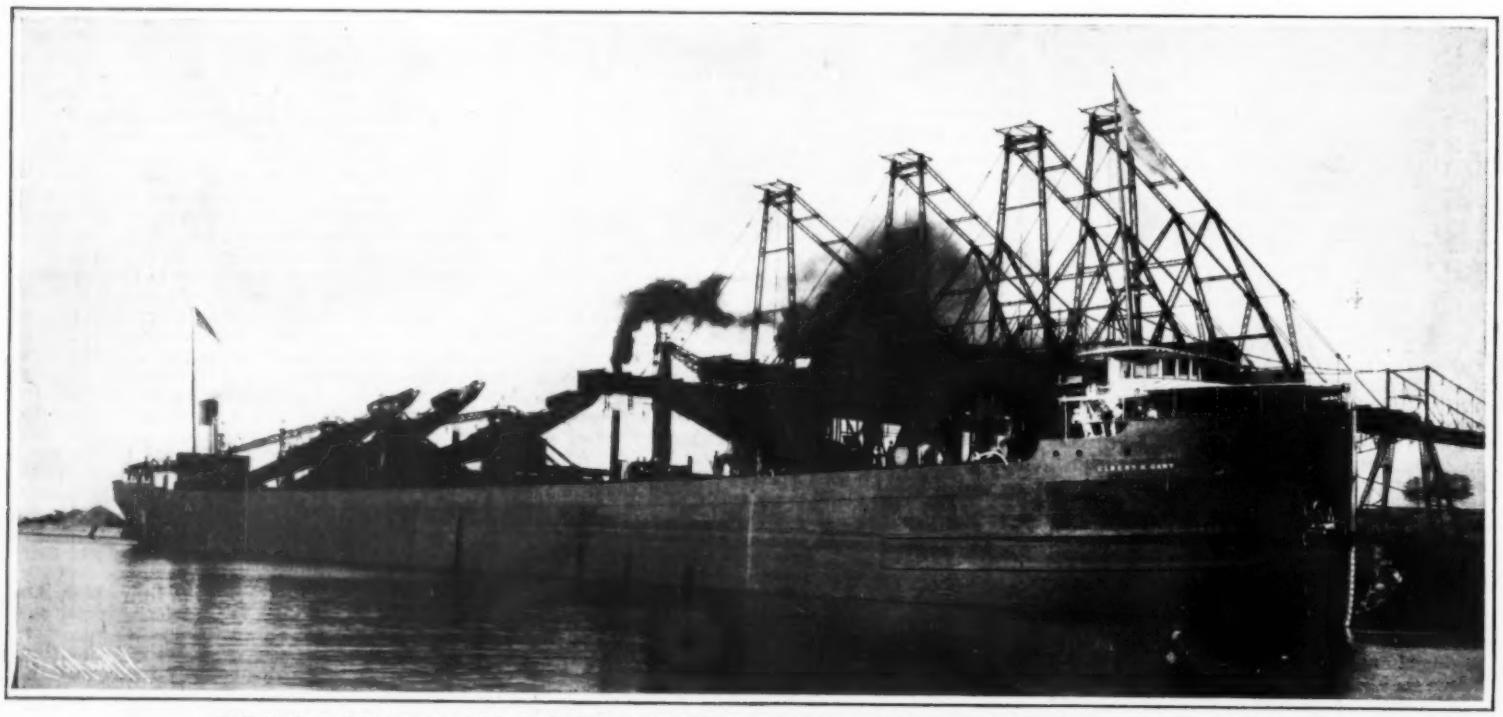
PACIFIC OCEAN STEEL-HULL STEAMSHIP "COREA."

HAND AND POWER RIVETING MACHINES.

The first hand riveting machine of which there appears to be any record is one described by William Fairburn in 1839, in a paper read before one of the British engineering societies, in which he says in part: "A riveting machine for riveting steam boilers, or vessels of wrought iron or copper, that completes eight rivets of ¾-inch diameter in a minute, with the attendance of two men and two boys to the plates and rivets."

In this country hand work appears to have been the only means employed in riveting steam boilers to about 1854, when we find in an engineering journal a description of a riveting machine used at that date: "Riveting machinery is unusual in this country. One or two machines in New York and two in Philadelphia are all that are in use in the United States. So far it has been successfully applied only to the riveting of plain cylinders, like boiler shells, flues, domes, etc. The rivet is formed and closed by compression between two dies; the one stationary in the side of a stout iron post, the other movable upon the end of a horizontal bar, operated by a cam and toggle joint. The cost of this machine is not far from $1,500 including the patent right. We saw the machine closing 12 rivets a minute, leaving nothing to be done saving trimming and calking the edges of the sheets. Three men attended the machine, while one hand heated the rivets, and another passed them to the machine. Two smart riveters will close up from 400 to 450 rivets in a day of ten hours, one hand heating, and one passing rivets as with the machine." The Port Richmond Iron Works and the Southwark Foundry at Philadelphia, Pa., and the Novelty Iron Works at New York city, had these machines in operation in their works at the time. It is not at all improbable that some of our locomotive works at the time had these riveting machines as one of their tools. There appears to be evidence that the Novelty Iron Works, of New York, had a hand machine for riveting iron boilers as early as 1843 or 1845, but whether it was an experimental machine or not does not appear.

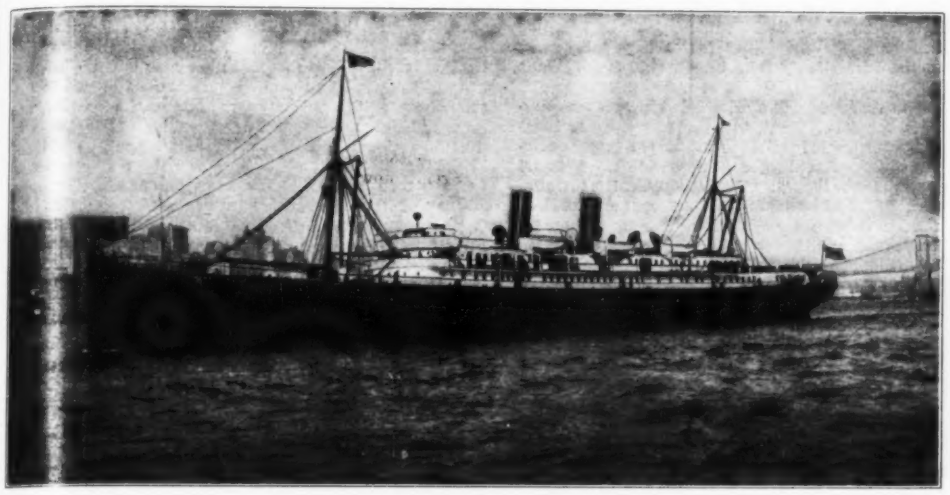
The power riveting machine first came into use in Great Britain before 1860. It was operated by a crank cam movement, but the work performed was very irregular. The steam riveter came to be used through necessity, at the time of a strike of the labor in one of the large plants, and was succeeded by the Twed-



MODERN STEEL-HULL ORE CARRIER "ELBERT H. GARY"—MACHINERY LOCATED IN THE STERN.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

dell patent hydraulic machine in 1871. This riveter was introduced in this country about 1876, and the patent was controlled by William Sellers & Co., of Philadelphia, Pa., for a few years. They built the first portable hydraulic riveter on the Tweddell system for the Edge Moor Works in 1873, and a stationary hydraulic riveter for the same works in 1877. This patent was subsequently managed in this country by the Morgan Engineering Company, of Alliance, Ohio.



STEEL STEAMSHIP "MORRO CASTLE," SAILING BETWEEN NEW YORK AND CUBA.

All of the stationary hydraulic machines, of whatever make, were termed "bull machines."

The steam riveter was the earlier of the power riveters built in this country. William Sellers & Co. built in 1868 their first stationary steam riveting machine for the Pennsylvania Railroad Company, and this was rapidly followed by similar machines for the Danforth Locomotive and Machine Company, Lehigh Valley Railroad Company at Hazelton, Pa., Baldwin Locomotive Works at Philadelphia, Pa., Dickson Manufacturing Company at Scranton, Pa., Schenectady Locomotive Works at Schenectady, N. Y., Manchester Locomotive Works at Manchester, N. H., and one for William Cramp Shipbuilding Company at Philadelphia, Pa., in 1872. Belt-driven shears and punches were in use long before these dates. A little later, direct power shearing machines, to trim the edges of the long and heavy iron plates, were brought into use.

The weak point in the direct-acting steam riveter was that inasmuch as the work performed was done by a blow, the shock was in time destructive to the machine itself, and very often injurious to the work operated upon. The subject of riveting by power had for some time attracted the attention of mechanical engineers, as about 1870 so much heavier material was being used in construction of iron vessels, bridges, etc., that it was no longer possible to work to advantage with the old-fashioned hand machines. The objections to the steam riveter were subsequently met by the hydraulic power machine.

The pneumatic portable riveter was first brought into notice through J. F. Allen's portable pneumatic riveter, that was patented in March, 1877, but was a few years later much improved. It was first brought into use in 1879 at the J. B. & J. M. Cornell works at New York city, Cambria Iron Works, Johnstown, Pa., Lane & Watson Boiler Works, Bridgeport, Ct., and in 1881 John Roach & Son, Chester, Pa.

The direct use of electricity to operate the large tools in the machine and boiler shops of the large plants has been of very recent date. It was in use ten years or more ago to operate the compression machine of the pneumatic riveter, that made it but an auxiliary power to the riveter. The pneumatic and electric riveter has come largely into use since about 1895, when large bridge work, the steel framing in the "skyscrapers" of our large cities, and the elevated railroad structures of our cities began to assume such

IRON AND STEEL SHIPBUILDING PLANTS.

	1880	1884	1890	1894	1898	1904
Atlantic coast	13	12	14	18	23	22
Northern lakes	3	4	8	8	10	10
Western rivers	3	3	3	2	3	4
Pacific coast	0	1	1	2	4	4

large proportions. The keen competition in iron structural work has been the cause of the invention and improvement of power machines and tools of the later years. There is probably no one section of this country where this strife for the best labor-saving machines, for the construction of iron and steel vessels has been carried further than in the comparatively new plants on the northern lakes.

IRON AND STEEL SAILING VESSELS.

At the time of the expansion of iron shipbuilding in 1870, the cost of material and labor was such as to make it almost prohibitive in constructing iron-hull sailing vessels. Wood was so much cheaper as a material for construction, and freight rates were too low in price to permit of the building of an iron-hull vessel, to make it a profitable investment to the owner. But we made history very fast in this line in a few years. Labor-saving machinery soon began to take form in our machine shops and shipyards, and by 1880 much of the work that had formerly been done by hand was now executed by power, and with the lower prices for ship iron or steel, it soon had its effect to lower the price per registered ton of the completed vessel. These conditions were taken advantage of by our vessel owners, and since then several iron-hull sailing vessels have been constructed. At the present time these vessels are of the type of the large six and seven masted fore-and-aft schooners.

The first iron-hull sailing vessel built in the United States was the schooner "Mahlon Betts," constructed by the Pusey & Jones Company in 1855, and enrolled May 16, 1855. The dimensions were 101 x 27 x 9 feet, 216 tons. Her original owners were Mahlon Betts, Pedrick, Price & Co., the builders of the vessel, and others. This vessel was under charter for several months during the rebellion to the Army Department. She was totally destroyed by fire while lying in Little Egg Harbor, N. J., on May 30, 1863, while on a voyage from New York to Washington. The next was the iron brig "Novelty," built in 1868 by the Atlantic Works at East Boston, Mass., for Spaulding, Nash & Co., of Boston, to transport molasses in bulk from the West Indies. The vessel was 130 x 27 x 11 feet, and the cargo space was divided so as to form seven tanks to hold the molasses. These tanks held about 90,000 gallons. The vessel ran to Matanzas, Cuba, mainly, and was in active service until April 1, 1874, when she sprang a leak during a gale on the coast and was lost. Reaney, Son & Archbold, at Chester, Pa., constructed a sloop yacht in 1871 named "Vindex," of 37 tons, having dimensions of 63 x 17 x 8 feet. The largest sailing vessel that had thus far been built was the "Iron Age," a bark built by Harlan & Hollingsworth Company for Tupper & Beattie, of New York, and launched October 30, 1869. Her registered tonnage was 650 tons. The cost of this vessel was $85 a registered ton for the hull, and $15 a ton for the rigging and outfit. The same builders in 1879 constructed a yacht named "Mischief," of 41 tons, having an iron hull. The William Cramp Ship and Engine Building Company built the first three-masted iron-hull schooner in 1880, named the "Josephine." This vessel was 126 x 34 x 10 feet deep in the clear, and is still in service with Mobile, Ala., as the home port. The first cost was $95 a ton complete. The American Shipbuilding Company, of Philadelphia, Pa., built the next three-masted schooner with an iron hull in 1884, named "Red Wing," of 415 tons with dimensions of 136 x 33 x 12 feet. Up to this time the vessels built were comparatively small sailing vessels, but in April, 1883, the Delaware River Iron Shipbuilding and Engine Works launched the iron-hull ship "Tillie E. Starbuck," of 1,829 tons, for W. H. Starbuck, for service on the Pacific Ocean. In the following September the American Shipbuilding Company, of Philadelphia, Pa., H. H. Gorringe, president, launched the ship "T. F. Oakes," of 1,897 tons, for the same party and the same service. The next year the same builders launched another ship named "Clarence S. Bement," of 1,727 tons. There now came a long interval of time before the metal-hull sailing vessel was again under construction; and during that period the wooden-hull, schooner-rigged sailing vessel had advanced from the four to the five masted vessel and from 900 to 1,600 tons, and steel was now used in place of iron.

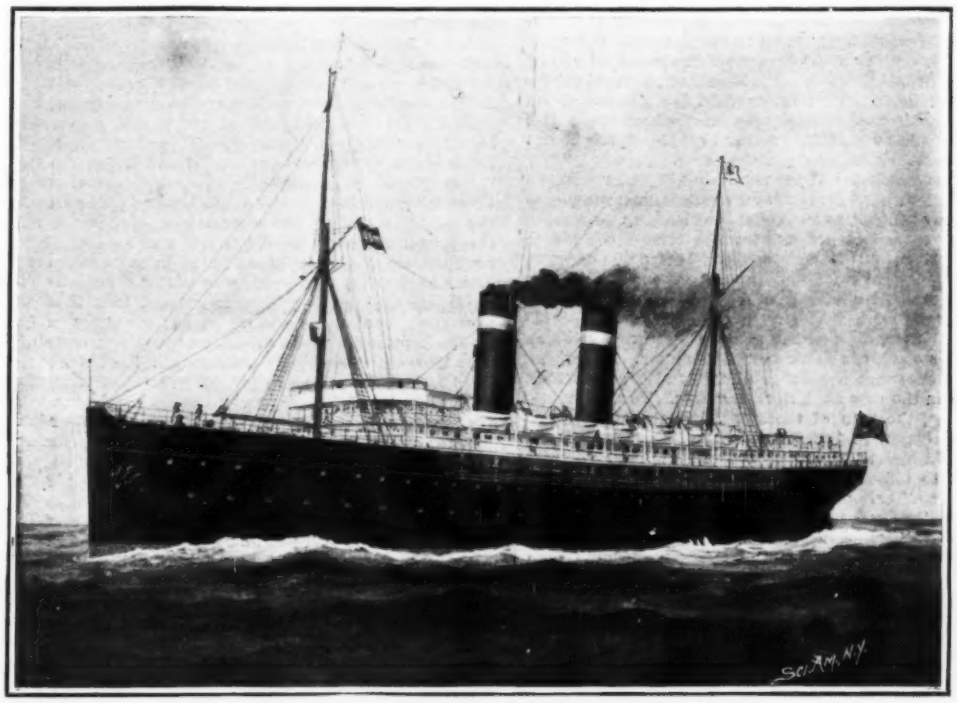
Those constructed later include: Ship "Dirigo," built 1894, 2,845 tons, Bath, Me.; ship "E. M. Phelps," built 1898, 2,715 tons, Bath, Me.; bark "Kaiulania," built 1899, 1,430 tons, Bath, Me.; ship "Edward Sewall," built 1899, 2,916 tons, Bath, Me.; ship "Arthur Sewall," built 1899, 2,919 tons, Bath, Me.; ship "Acme," built 1901, 2,987 tons, Bath, Me.; ship "W. P. Frye," built 1901, 2,998 tons, Bath, Me.; ship "Astral," built 1901, 2,987 tons, Bath, Me.; ship "Atlas," built 1902, 3,006 tons, Bath, Me.; schooner "Thomas W. Lawson," built 1902, 4,914 tons, Quincy, Mass.; schooner "Kineo," built 1903, 1,867 tons, Bath, Me.; schooner "W. L. Douglass," built 1903, 3,470 tons, Quincy, Mass.

There have been built on the northern lakes since

AVERAGE PRICES OF IRON AND STEEL SHIPBUILDING MATERIAL DELIVERED AT SEABOARD, OR ON THE NORTHERN LAKES, FROM 1882.

	1882	1883	1885	1886	1888	1890	1895	1897	1899	1900	1902	1904	1905*
Iron shell	4	3	2.75	2.4	2.4	2.5	1.25			1.4			
Iron flange	5	4	3.25	3.4									
Iron firebox	6	5	4.75	4.25									
Iron angles	2.9	2.4	2.4	2									
Iron beams	4	3.5	3	3									
Iron channels	4.2	3.5	3	3									
Iron shell plate	3.6	2.5											
Steel ship plate	5½	4½ to 5	3.25	3	2.3	2.4	1.30	1.30	2.70	2.60	2.30	1.75	1.73
Steel plate boiler and flange	7	5¼ to 5¾	4.75	3.5	3.75	2.8	1.60	1.30	2.90	2.30	3.00	1.85	1.88
Steel angles				2.35	2.10	2.4	1.85	1.25	2.15	2.40	2.60	1.55	1.74
Steel beams				4	3.3	3.10	1.40	1.50	2.15	2.60	2.70	1.85	1.86

* For nine months.



ATLANTIC OCEAN STEEL STEAMSHIP "ST. LOUIS."

1894 several schooner tow barges having a steel hull, and a few of them having the tonnage measurement of 4,000 tons. These vessels are fitted with short masts, mostly three in number, and are furnished with sails for use in case of emergency only. They have no use on these lakes for the large schooners such as the "Thomas W. Lawson," as the cargo steamers on those inland waters carry their freight at such a low rate that sailing vessels cannot successfully compete with them.

[Concluded from SUPPLEMENT No. 1559, page 24987.]

THE STATURE OF MAN AT VARIOUS EPOCHS.*

By A. DASTRE.

AT Berlin the scholars brought into prominence reasons why the anthropopithecus could not be a man; at London they showed why it could not be an ape. So nothing was left the transformists but the conclusion that the creature, which was neither a man nor an ape, must be both at the same time, and that it constituted the transition stage from ape to man, the "missing link" of the chain that binds the human to the animal kind. E. Dubois assigned a height of 1.70 meters to the anthropopithecus; the estimate of M. Manouvrier is somewhat less. The length of the femur permits us to attribute a height of about 1.65 meters, the average height of the European, to this precursor, this original ancestor of man.

After measuring skeletons of the Tertiary epoch, as was done by M. Manouvrier, it was necessary to do the same for those of the Quaternary epoch. The task was undertaken by M. Rahon.† The most ancient specimen of that period is the skeleton of Neanderthal, found in 1857 in a limestone cave of Neanderthal, between Düsseldorf and Elberfeld. The first measurements, made by Prof. Schaafhausen, showed that the relative proportions of the members were those of a European of average size or a little below the average. Schaafhausen determined the height to be 1.601 meters; Rahon's estimate, 1.613 meters, is almost the same.

It would be idle to give in detail similar measurements made of all the human bones of the Quaternary period that MM. Manouvrier and Rahon had before them either in the original or in casts. They computed the height of the man of Spy to be 1.610 meters, that of the man found in the clay of Lahr 1.720 meters. The latter, as is apparent, belonged to the group of "tall-bodied" men. The troglodyte of Chancelade, found in the more recent strata of Quaternary soil, was 1.612 meters, the crushed man of Laugerie 1.669 meters. The average for the four cases is 1.652 meters.

These figures would indicate but a moderate size in our distant ancestors, who were contemporaries of the cave bear and chased the mammoth and the rhinoceros of the chambered nostrils. They in no wise resemble the colossal beings created by popular fancy and described by the poets as "more massive than the cedar and taller than the pine." Nor were they "stronger than the oak." They lived more or less miserably. The men of the Quaternary period had already begun to be industrious and they fashioned implements of roughly hewn stone. This was the beginning of the paleolithic or old stone age. It must have lasted a very long time, to judge from all the succeeding changes of climate and water courses.

The following age is the neolithic or new stone age. Its duration was also very long, sufficiently long for Europe to be covered with its megalithic monuments and sepulchral structures. It was the time in which the cutting of flint, carried on toward a state of perfection, ended in the fashioning of various instruments for fishing, hunting, or fighting. These lost the rude character of the utensils in the preceding age, and the polishing of flint marked a turn in the affairs of prehistoric man.

The bony remains of the neolithic age underwent the same patient investigation and the same measurements as those of the paleolithic age; and Rahon and Manouvrier succeeded in determining the size of the people of this time, as of the preceding. Here the facts to work upon were much more numerous, for the number of skeletons that have been extracted is considerable. Conclusions were drawn from the examination of 429 men and 189 women. The average stature of the men is 1.645 meters, of the women 1.526 meters. But among these there were a number of tall and short persons, just as is the case at the present time. To cite several instances, the man of the Madeleine, the station next to Les Eyzies, in the department of Dordogne, measured 1.86 meters. The bones found at Les Eyzies belonged to still larger types. In this region Christy and Lartet exhumed from the cave of Cro-Magnon three well-preserved skeletons, which have given rise to observations of extreme interest to anthropology. They were the skeletons of an old man, an adult man, and a woman, and they have served as types for the establishment of a race become celebrated under the name Cro-Magnon. On a merely superficial examination of the bones, one can tell that the persons must have been robust and tall. Broca unqualifiedly declared their stature to be superior to the Frenchman's; but since it was impossible to reconstruct a skeleton in its entirety, he was not in a position to make direct measurements and give an indisputable figure.

Therefore it was with some hesitation that he assigned to them a probable height of 1.80 meters. Broca, it must be stated, for aid in his reconstruction could not fall back upon tables that would have enabled him approximately to deduce the size of the entire body from nothing but the measurement of a single bone like the femur. Tables of this sort, it is true, existed in his time, provided by physicians who practised forensic medicine, but they did not inspire him with confidence because the relations between the various parts of a skeleton had been established according to the principle of Paris or Lyon—that is, for the human structure as represented by the existing race of Frenchmen. But it is known that the relations between the various parts of the body are not the same in all the races of the present day; the principles for each are different. So much the more likely it is they would be different among prehistoric races. What is more, in a race like the French, there are two distinct types, each having the same measurement, but the one class is long-legged (macroscelic, in the term of the anthropologists), the other short-legged (microscelic). *A priori* it would seem as though all these difficulties would dash the hope of establishing a relation more or less fixed between the segments of a limb and the entire body. But these are the very difficulties that the methods of anthropometry were devised to overcome, and, as has been said, the method of Monsieur Manouvrier has succeeded.

Whatever the means employed (and it is useless to recall them here), Broca decided upon 1.80 meters as the height of the old man of Cro-Magnon. Some other investigators estimated it at 1.78 meters, and Topinard went so far as to say it was 1.90 meters, a figure altogether exceptional and unexampled up to this time in the case of prehistoric man. The estimates of Rahon and Manouvrier were lower. They fixed the height of the old man at 1.736 meters; that of the woman at 1.658 meters, and that of the adult man at 1.667 meters. Even these numbers betoken great height, superior, certainly, to the average height of the inhabitants of France. The race of Cro-Magnon, then, was a race of tall-bodied men.

The stature of the man of Mentone, whose skeleton was discovered by Rivière in ground of the neolithic period of the Quaternary age, was even larger. The caverns which exist in the red escarpments rising from the broken stone road between Mentone and Vintimille have furnished a fair number of bones, the last specimens being those of a child, a woman, and a man. Their fragility does not permit of their being handled and renders their measurement a delicate operation. From the tables of Monsieur Manouvrier the height of the man is calculated to be 1.752 meters. Monsieur Rivière had reckoned it to be from 1.95 to 2 meters. It is clear that if one should consider the man of Mentone as the average type of the man of his time, the race to which he belonged would have been superior in stature to that which inhabits the same country today. They would have compared in size with the tallest actual races of Europe, the Scandinavians or the Scotch. But there are many reasons for supposing that the man of Mentone ranked in the series of tall-bodied persons among the men of his own race.

In examining specimens of races inferior in stature to the French we find the man of Bolwillier measuring 1.60 meters; the skeleton in the sepulchral Caverne de l'Homme Mort in the department of Lozère, 1.62 meters; that in the cave of Géménos, 1.67 meters; in the cave of the valley of the Rousson, in the department of Gard, 1.63 meters. The man of the cave of Orrouy, in the department of Oise, represented a vigorous race and was 1.64 meters tall.

It would be irksome to prolong the enumeration. All the caves and caverns that have delivered up their human bones to the curiosity of anthropologists, the contents of all the sepulchral crypts, all prehistoric burial places, the dolmens of Belgium, of Quiberon, those in the departments of Lozère and Indre, the sepulchral vaults of a dolmenic character, like those of Crécy en-Vexin, the covered alleys like that of Mureaux, the peat districts of the department of Somme, and the dolmens of Algeria—the contents of all these have been examined and the bones found in them measured. The measurements made of more than 400 subjects (to be exact, 429) give us a more correct idea than we previously had of the stature of our ancestors in the neolithic period, and we are able to say with certainty that they were perceptibly shorter than the Frenchmen of to-day, their average height being 1.645 meters; that of the French, 1.650 meters. Therefore it is not true that we have undergone an evolutionary process of degeneration. It would be false to state that primitive man was our superior in stature.

Anthropological investigations bearing upon historic times scarcely offer anything more of interest to us, for one can tell in advance that measurements of the body would not furnish different results from those already set forth, since the stature of men of our race, which did not vary in the course of thousands of centuries during a period of extraordinary changes, would certainly not undergo perceptible variation in the course of a few hundred years during which conditions of existence have sustained but insignificant changes in comparison with those of preceding periods. Such, in fact, is the very conclusion to be drawn from the examinations made by Rahon and Manouvrier of the bones of human beings in various epochs of the historic period. In the first group they place the bones that may be called proto-historic, since they belong to a time the date of which has not been exactly fixed and of which no records remain. For example, in the museum of natural history (Paris) there is a collection of bones gotten together by M. de Morgan from the dolmens of the Caucasus near Koban and belonging to men who lived at an epoch not exactly determined, which corresponds to the age of iron. These men are of those who constructed the megalithic monuments of Roknia and of the Caucasus, in which their remains are found. Their stature is hardly larger than that of the actual inhabitants of the country, the men reaching a mean height of 1.673 meters and the women 1.564 meters. According to Schortt, the average size of the present natives of Caucasus is 1.650 meters. Therefore we have an average height almost the same as that of the French.

In turning to France, an examination of the skeletons found in the Gallic or Gallo-Roman cemeteries of Vert-la-Gravelle, of Jonchery, and of Mont-Berny reveals a height of 1.66 meters in the men and 1.55 meters in the women. The Frankish populations buried in the sepulchers of the Department of Marne were 1.67 meters in height; those of the cemetery of Ramasse in the Department of Ain, considered to be Burgundians by M. de Mortillet, showed a height of 1.666 meters for the men and 1.538 for the women. The average stature of these peoples, who occupied France in the Gallo-Roman epoch, was a bit higher than that of the French nowadays, but not so much higher as one would suppose from the remarks of historians. With each investigation of each epoch the same conclusion is reached, and we repeat it as though it were the refrain of a couplet: Man's stature in the proto-historic period, as in the preceding period, was almost invariable.

The final researches of M. Rahon bear upon the Parisian population from the fourth to the eleventh centuries. The cemetery of Saint-Marcel was used in the fifth and sixth centuries, that of Saint-Germain-des-Prés, more recently, in all likelihood in the tenth and eleventh centuries. The comparison and measurement of bones from these two cemeteries show that the average height of men and women is the same for both burial places, being 1.677 meters in the case of the men and 1.575 meters in the case of the women. The result gives rise to two observations. One is that in the course of six centuries the average height of Parisians has maintained a remarkable fixity. The other observation bears upon a comparison with the present stature of Parisians. A difference of nearly 1 centimeter (7 millimeters) in favor of the mediæval Parisians exists between the average height of present Parisians and those of the middle ages.

This is at once a great deal and very little. The greater size is explained by the fact that the bones which were put aside, guarded in collections, and finally submitted to measurement were the best preserved, the most solid, and those, in consequence, which, having most successfully resisted destruction, proved in themselves that they had belonged to the select. One such circumstance is sufficient to explain a slight difference of some millimeters.

It may be admitted as the result of pretty general experience—the result, in fact, which arises from all that has so far been said in the present article—that when a race or people is sufficiently homogeneous, when it is not too mixed with other very dissimilar races, the average height is found to remain the same, provided enough measurements have been obtained. In the course of time it becomes invariable; it provides significant indications of great value. The ameliorations of conditions of existence, which would appear to increase stature, does so only indirectly by eliminating a greater number of exceptional cases, which lower the average in a factitious manner. It excludes from comparison persons who, through disease or sickness contracted during the period of growth, have not developed harmoniously, or attained their full height.

Nevertheless, it is important to state that the results announced some years ago by Manouvrier and Rahon have raised some objections. At first glance it is clear that all their measurements systematically lower the numbers generally assigned to man's height. In many cases the outcome of their exact methods contradicts not only general opinion, but the affirmations of historians and the results of approximate measurements. Objection was raised before the society of anthropology. A. Hovelacque, in particular, expressed his astonishment at the very low figure at which M. Rahon estimated the height of the Burgundians of Ramasse. All ancient authors agree in declaring the Burgundians, a Teutonic people, originally from North Germany, between the Oder and the Vistula, to have been extremely tall men. According to the measurements of M. Rahon they were only a little above the average (1.666 meters). If, as M. de Mortillet says is true, the men buried at Ramasse were Burgundians, and if the number of skeletons examined is enough to establish an average, one sees the consequences of the flagrant contradiction between anthropology on the one hand and historic evidences on the other.

M. Manouvrier replied to the objections made by A. Hovelacque. He declared that this contradiction did not affect him, since the determination of the size of the body from exact measurements of the long bones was an operation sufficiently precise to carry greater weight than the assertions of historians and geographers. Even the most exact historians, like Herodotus, Cæsar, and Strabo, were capable of exaggerating the size of the people of whom they wrote. We have seen how the navigators and explorers of the eighteenth century, in speaking of the Patagonians, of individuals whom they themselves had seen, gave varying descriptions of them. Some set their height down as 6 feet, others at 7½ feet or more. Such facts as this may well put us on our guard against illusions of the eye, and still more against those of the imagination.

Even so, the figures given in regard to the height of the Burgundians indicate that they were a tall-bodied race. Their stature is 16 millimeters, or nearly 2 cen-

* Translated from Revue des Deux Mondes and published in the Smithsonian Annual Report.

† It must be stated that the figures here given refer to the fleshy body, not to the skeleton. They give the length of the corpse as it would measure if stretched on the ground. Man erect and living measures 2 centimeters less.

timeters, more than that of the average Frenchman of to-day. And such a difference is not a negligible quantity. It makes an impression upon the eye, gratifying in its certainty, and it corresponds to the difference of judgment expressed when we say of a man that he is middle-sized, or of another that he is tall. For example, we call the Sardinians short and the Belgians tall; yet the average height of the Sardinians is only 2 centimeters less, and of the Belgians only 2 centimeters more, than that of the French.

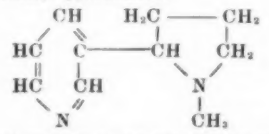
The general conclusion of the studies sketched in brief in the present article can be nothing but a repetition of the conclusions reached at the end of each special study. The bones of primitive man, of prehistoric man, and, finally, of historic man, when submitted to examination, show that man's stature has experienced no appreciable changes in the course of time, has shown no traces of an evolutionary degeneration. We are not a stunted posterity, and we have the right to spurn the insult of the poet who says that "we are dwarfs beside our fathers."

THE CHEMISTRY OF TOBACCO.

The tobacco industry has at the present day grown to very large dimensions. The total world's production of this plant is estimated at 2,200 million pounds per annum, of which about 770 are contributed by Asia, 660 by America, 550 by Europe, and 35 by Germany. An idea of the revenue derived by governments from tobacco can be gathered from the fact that in France it figures out to about $1.75 per head. The price of different brands varies within wide limits; while Kentucky plug can be bought for 15 cents per pound, the best Havana will fetch $35 to $50.

As regards the chemical composition of tobacco, the first point to note is the high percentage of mineral matter generally, and of potash and lime in particular. The tobacco leaf contains on an average 15 per cent of pure ash, consisting of 30 per cent potash and 36 per cent lime. It is evident from this that the tobacco plant can flourish only in a soil rich in these two bases.

A constituent of tobacco which is of particular interest is the alkaloid nicotine. This has recently been synthesized by Pictet, whose work confirms the formula proposed twelve years ago by Pinner, the body being a product of condensation of one molecule of pyridine and one of methyl pyrrolidine:



The method usually employed for the determination of nicotine in tobacco is to render the material alkaline, extract with ether, and to isolate the nicotine by steam distillation. The nicotine content of tobacco varies from 0.5 to 5 per cent. A cigar with more than 2 per cent of this alkaloid is quite strong, one with about 3 per cent can hardly be smoked.

Two other important constituents of tobacco are the fixed organic acids, especially malic and citric acids, and the tobacco resins. The former are important factors in determining the smoldering of the material, while the latter largely influence its aroma. Tobacco contains on an average 8 to 10 per cent of these two classes of substances.

The method of cultivation of the tobacco plant presents some points of interest. The seed is first of all sown in carefully prepared beds, and after eight weeks or so the young plants are transplanted to the open fields. As they grow, the inflorescence and the lateral shoots are cut off, so as to encourage as far as possible the development of the leaves; finally these are gathered when ripe.

The tobacco seed is exceedingly small, about 780 seeds weighing one grain. About 50,000 seeds are sown per acre, of which only about one-third develop into plants. The tobacco plant requires a very loose soil, and the ideal soil for it is the layer of humus which is left on the land after deforestation, such as exists in particularly fine quality in Sumatra. Unfortunately, this virgin soil loses its valuable qualities very largely even after the first crop. In the tropics it has been found possible to work with an alternation of crops, growing tobacco for one to two years, and then allowing the land to become covered with woods during a period of six to eight years. This of course is possible only in the tropics.

In consideration of the high potassium content of tobacco, particular interest attaches to the question of suitable potash fertilizers for this plant. Nevertheless, nothing positive can be stated as to the best mode of fertilizing, all observations made hitherto having failed to lead to any definite conclusion.

Much interest has also been aroused by a method which was said to produce excellent crops on old fields, and which consists in growing the tobacco under sheds. According to the latest reports, however, it appears that although this method has proved very satisfactory in Cuba, protecting the plants from excessive solar radiation, in Connecticut the attempts made in this direction have proved a complete failure. The matter can not, however, be considered settled.

An aim which naturally suggests itself, that of producing a tobacco which combines in itself the advantages of the Havana and the Sumatra varieties, is not likely ever to be realized, as these two, in order to have their special qualities properly developed, require totally different treatment during their period of growth.

A point which has been much studied, but which, owing to its complexity, is very difficult to clear up, is the influence of the methods of cultivation on the smoldering quality of the tobacco. But so much seems to be established, that potassium has a favorable influence, while the opposite is true of chlorine, and further, that the favorable effect of potassium is marked only if a considerable proportion of that base is bound to fixed organic acids, i. e., when the ash has a comparatively high basicity. According to P. Wagner, the percentage of potash in the dry material must not sink below 5 per cent, that of chlorine must not exceed 0.6 per cent. A high percentage of organic acids favors the smoldering process, more especially in that it leads to the formation of a loose ash. As regards the influence of the other organic constituents, opinions diverge, but it seems fairly certain that the albuminoids affect the smoldering less than the odor of the products of combustion, upon which they have an unfavorable influence, while the resins, on the contrary, are prejudicial to good smoldering qualities. The structure of the leaf is apparently also of great importance. The conditions are evidently complex, so that it is easy to form erroneous conclusions from field experiments.

During the drying of the tobacco, which has to be performed with care, the carbohydrates disappear, the albuminoids are decomposed, with formation of amides, the brown, incompletely investigated tobacco pigments are formed, etc.

Very interesting are J. Mohr's investigations on the migration of substances which takes place in the tobacco leaves left on the plant. Mohr has shown that a number of substances pass from the leaf into the stem, namely, those which are of physiological value. The plant withdraws from the dying organs, the leaves, the materials required for the nourishment of the lateral shoots and the inflorescences, i. e., the parts upon which depends the perpetuation of the species. Lime and magnesia are left almost entirely *in situ*, sulphur is transferred in greater quantity, next come chlorine and potash, and highest of all stands phosphorus. As regards the organic constituents, the starch is dissolved, the sugar is partly oxidized off by respiration, partly transported to the stem. Amido and amino compounds are transported freely, and also ammonia, while nitrates and albuminoids show much less tendency to migrate, and least of all does the nicotine.

The fermentation of tobacco is a process which goes on with spontaneous liberation of heat, and which, according to Suchsland, is determined by certain bacteria, while Löw maintains that it is due to enzymes, of which he has isolated a number. Two methods of fermentation are used. In the one case the bunches of leaves are stacked up in heaps, and the temperature, which soon rises naturally, is kept at about 60 deg. C. by frequently opening up the heaps and resetting them. In the other case the bundles are hung up loosely. In this latter method, in which also the temperature is carefully regulated, a very much more extensive oxidizing action takes place. This method is principally used in North America. Each of the two processes has its advantages and disadvantages, but for the better qualities of tobacco the fermentation in heaps seems to be preferable.

A good deal of energy has been expended by inventors on the attempt to free tobacco from its most active poisonous ingredient—nicotine. The idea appears to be prevalent that what is wanted is a suitable oxidizing agent, and so the patent literature contains a somewhat fantastic selection of oxidizing processes which have been proposed. Probably the best attempt in this direction is that of Siemens & Halske, who effect the oxidation by means of their ozonizer; recent tests of this process, however, seem to indicate that no notable success can be gained by this means.

The numerous patents dealing with the removal of nicotine from tobacco can be divided into four classes: 1. Those depending on the extraction of the nicotine. These suffer from two flaws: first, they are too expensive, and secondly, they mostly injure the quality of the tobacco. 2. Those depending on the volatilization of the nicotine. Little is known about these. 3. Processes depending on the fixation of the nicotine. This fixation is generally quite ineffective, for in the smoldering of the tobacco the nicotine is again liberated. 4. Processes depending on the absorption of the nicotine in the smoke. To the chemist who is familiar with problems of absorption, the question will immediately suggest itself whether any approachingly complete absorption can take place when the smoke is passed at a comparatively high speed through the absorbent.

The composition of tobacco smoke has been fairly completely investigated. Its strongly poisonous constituents are nicotine, pyridine, an empyreumatic oil of unknown constitution, carbon monoxide, hydrocyanic acid, and sulphureted hydrogen. The last three occur in such small quantities that they hardly enter into consideration as regards the physiological action of tobacco smoke. The most important of these constituents is nicotine; chronic tobacco poisoning resembles acute nicotine poisoning very closely.

The percentage of nicotine in the smoke is in general determined only by the nicotine content of the tobacco from which it is produced, but the relative proportion of nicotine which passes from the cigar into smoke depends principally on the length of the unconsumed portion of the cigar, as the nicotine content of this portion is inversely proportional to its length. Only a comparatively small proportion of the nicotine is destroyed in the process of combustion of the tobacco.

The advice to be given to any person who has cause to avoid the effect of the heart and nerve poison nicotine, and who nevertheless can not resign himself to abstain from smoking, or to smoke only tobacco free from or poor in nicotine, is that he should always smoke only so much of each cigar as to leave about three eighths unconsumed.—From an article by R. Kissling in the Zeitschrift für angewandte Chemie.

CONTEMPORARY ELECTRICAL SCIENCE.*

ABSORPTION AND RÖNTGEN RAYS.—In his third communication on X-rays Röntgen pointed out that any Röntgen rays that have penetrated a certain substance are absorbed much less by a second layer of the same substance, that they acquire, in fact, a greater power of penetrating the same substance than they possessed before. This was explained on the supposition that the rays are mixed, and that the less-penetrating rays are absorbed first. This explanation can only be adequate if the rule applies to every known substance. Now, B. Walter points out that it does not so apply. Aluminium, iron, copper, zinc, platinum and lead do obey the rule, but silver and its allied metals do not. When the rays are transmitted through silver, and, to a less extent, through palladium, cadmium, tin and antimony, their power of penetrating the same metals is reduced instead of increased. The author attributes this to a peculiar effect of the atom in changing the character of the rays it absorbs and in producing secondary rays characteristic of the metal. As a practical application he proposes to protect the outer skin in deep radiographs by transmitting the rays first through a substance as similar as possible to the skin itself.—B. Walter, Fortschritte der Röntgenstrahlen, vol. viii., 1905.

THERMO-DYNAMICS IN ELECTRICAL PROBLEMS.—H. A. Lorentz studies the principles of Carnot and Clausius in their application to electricity, and more especially to thermo-electricity. He points out that their general validity is limited by the definite side of the electron. Thus, if a body having a certain temperature and surrounded by reflecting walls emits a radiation which imparts a certain density of energy to the ether, one can conceive a body whose molecules have the same kinetic energy and which yet produces only one-eighth of the former density of energy in the ether. It suffices to double all the linear dimensions, including the diameters of the molecules, atoms and electrons, and to multiply the electric charges by $\sqrt{2}$. Two such bodies are conceivable, but they cannot coexist actually owing to the fixed size of the electron. Among other applications of thermo-dynamics and the kinetic theory, the author gives a lucid account of thermo-electric force, which he ascribes to a kind of distillation of electrons from a metal containing many to a metal containing few per unit volume. This distillation is limited by the electric field set up in both bodies, the body which loses the electrons becoming positively charged and preventing any further electrons from escaping.—H. A. Lorentz, Bulletin, Société Française de Physique, No. 1, 1905.

NATURE OF GRAVITATION.—W. A. Nippoldt formulates a new kind of Lesage theory of gravitation, in which the part of the ultra-mundane particles is taken up by ordinary matter. Dividing the total masses in the solar system by its volume as a sphere he obtains its average density, and finds it to be of the order of the density usually attributed to the ether, viz., 10^{-22}. He regards the ether as superfluous in explaining gravitation. All matter is in motion, and the smaller the aggregation in which the matter takes part the greater is its maximum velocity. Hence "open space" is filled with minutely subdivided matter in rapid motion in all directions. All larger masses are subjected to bombardment by these minute particles, which are small enough to penetrate between the molecules, and are stopped or reflected in proportion to the mass of the body bombarded. Two masses in space shield each other from the bombardment on one side, and are, therefore, apparently attracted toward that side. An absorption of the minute particles would after a long time give rise to an increase of mass of the body, but such an increase might be compensated by the projection of corpuscles as it goes on in radio-active bodies.—W. A. Nippoldt, Jahresbericht, Phys. Verein, Frankfurt, 1903-4.

ALUMINIUM STEEL.—L. Guillet shows that aluminium dissolves in iron to a maximum extent of 15 per cent. As long as the admixture of aluminium remains below 2 per cent it exerts no effect upon the mechanical properties of the iron. At 7 per cent it becomes extremely brittle. If an aluminium steel is tempered at a temperature above 850 deg., a martensite is obtained which strictly occupies the place of the perlite in the non-tempered steel. The solution of aluminium in iron is, therefore, incapable of dissolving carbon. As regards the steels containing cementite, the influence of tempering is the greater the higher the temperature. While up to 950 deg. only troostite is obtained, martensite is formed at 100 deg. The effect of tempering on mechanical properties corresponds with the micrographic evidence. In no case does the annealing of an aluminium steel give graphite. If one attempts to cement a steel containing more than 50 per cent of aluminium, the penetration is exceedingly slow. Besides, cementite is formed instead of perlite. The steels with a high percentage of aluminium often contain free martensite although the proportion of carbon is less than 1 per cent.—L. Guillet, Comptes Rendus, July 3, 1905.

* Compiled by E. E. Fournier d'Albe in the Electrician.

SOME CURIOUS PHENOMENA OF RAINFALL.

THERE are few more familiar sights than rain, and the method of its formation from the water vapor in the atmosphere is also, apparently, very simple. Yet the investigator, in studying the phenomena of rainfall more closely, continually meets with new problems.

We know that the condensation of atmospheric vapor may be brought about in various ways. It may be caused, for example, by the mere ascent of a mass of moist air and its resultant expansion. In other words, the energy consumed in expanding against the pressure of the surrounding air must be derived in the form of heat from the expanding air itself, and the cooling of the air thus effected is followed by condensation of part of its vapor, because the quantity of water that can exist permanently, in the form of vapor, in a given space, decreases rapidly as the temperature falls.

We have learned also, however, that condensation does not necessarily begin promptly upon the attainment of this so-called limit of saturation unless the space in question contains nuclei of condensation in the form of dust, minute drops of water or ice crystals already formed, or the electrified ions with which recent researches have made us familiar. In the absence of such nuclei, upon which vapor might condense into drops, a condition of supersaturation occurs which may be relieved by the sudden and copious precipitation which is known as a "cloud-burst."

We know, furthermore, that the very small drops, which are produced under normal conditions and form ordinary clouds, fall very slowly, because the resistance of the air, which increases very rapidly with the velocity, is also relatively greatest for the smallest drops, and sets a limit, small and quickly reached, to their velocity. The attraction of gravitation is proportional to the mass of the drop and hence to its volume or the cube of its diameter, while the opposing resistance is proportional to the surface or the square of the diameter. Doubling the diameter, for example, multiplies the weight or downward force by 8, but the resistance by only 4, and therefore increases the limiting velocity of fall.

Again, as all motion is relative, a drop that falls through still air with a certain velocity will be prevented from falling at all by a current of air ascending with that velocity and will be carried upward by a swifter ascending current. Hence mists and clouds remain suspended in the air.

There are various conceivable causes for the growth of drops to a size which makes such suspension impossible and, therefore, determines a fall of rain. Even if we assume that in a newly formed cloud all the drops are equal in size, a cold air current striking the top of the cloud may condense more vapor upon the upper drops and thus make them larger than the rest. Initial differences of size, due to corresponding differences in the nuclei of the drops, are also conceivable.

Now, when drops of different sizes exist together the larger must, as Lord Kelvin has proved on theoretical grounds, increase still further at the expense of the smaller, which diminish through evaporation. The larger drops will also increase by absorbing small ones which they overtake and strike.

Various attempts have been made to measure the masses and velocities of raindrops. Bentley has determined the relative frequency of drops of various sizes by exposing a box of flour to the rain for a short time and measuring the lumps of dough formed by the drops as they fell. The velocity of fall has been studied by means of photography. Each falling drop is represented in the photograph by a vertical line, the length of which, for a given time of exposure, is proportional to the velocity of the drop, but the photograph gives no definite information concerning the size of drops.

Lenard* has recently attacked the problem in the following ingenious way. Air was blown upward by an electric fan through a large vertical pipe, into the open top of which water was dropped. The speed of the fan, and consequently the velocity of the air current, was adjusted until the drop just failed to enter the pipe but, after hovering over it for a few seconds, glided away horizontally and fell outside. It was caught on blotting paper and its size was determined by a method which Wiesner had previously employed. Drops of various sizes were obtained by regulating the aperture of the dropping tube. The velocity of the air current was measured by an anemometer. This velocity is equal to the maximum velocity which the drop would have attained in falling through still air.

The following results were obtained:

Diameter of drop. Millimeters.	Velocity. Meters per second.
1.28	4.80
3.49	7.37
4.50	8.05
5.47	7.98
6.36	7.80

From these observations it appears that the velocity does not increase indefinitely with the size of the drop, according to theory, but reaches a maximum for drops 4.5 millimeters in diameter. This anomaly is explained by Lenard's discovery that very large drops do not retain their spherical shape in falling, but become deformed, flattened, converted into rings or even divided into smaller drops, so that the resistance is increased and the velocity correspondingly diminished.

Lenard made no observations on very small drops. For these the theoretical relation holds between size and ultimate velocity—the latter, though always very small, increases rapidly with increase of size, as the following table shows:

Diameter of drop. Millimeter.	Velocity. Millimeters per second.
0.01	3
0.02	13
0.10	320

Drops of diameters exceeding half a millimeter, on the other hand, show only such comparatively small differences in velocity as are indicated in the first table. Hence drops of such dimensions (to which Lenard restricts the name "raindrops") will collide comparatively seldom with each other but very frequently with the smaller and slower drops with which the cloud is, comparatively speaking, densely packed. These small drops must also, in view of their great differences in velocity, often overtake and collide with each other, and such collisions must be the cause of the first formation of larger drops, and the beginning of rain. From the estimated mean distance of minute drops in a cloud it has been computed that every such drop must meet others at the average interval of one minute. Yet large drops are not always formed, that is to say, not every cloud yields rain. The explanation of this paradox is that collision is not necessarily followed by coalescence unless sufficient time is afforded for the disposal of the intervening layer of air which, ordinarily, causes the colliding drops to rebound and separate instantly. Probably coalescence of minute drops, and consequently rainfall, is always due to the action of some extraneous force, which, according to Lenard, is electrical.

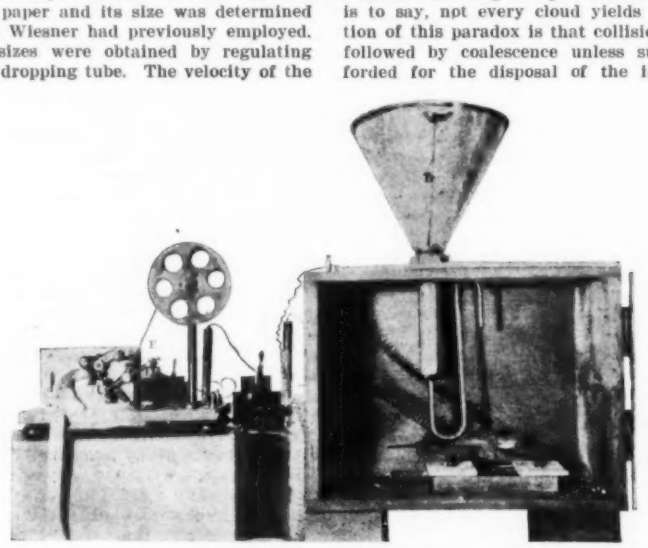


FIG. 2.—GALLENKAMP'S SELF-REGISTERING PLUVIOMETER USING A MORSE RECORDER INSTEAD OF THE ROTATING CYLINDER.

In either case, as the connection is electrical, the recording apparatus may be placed in any convenient position indoors.

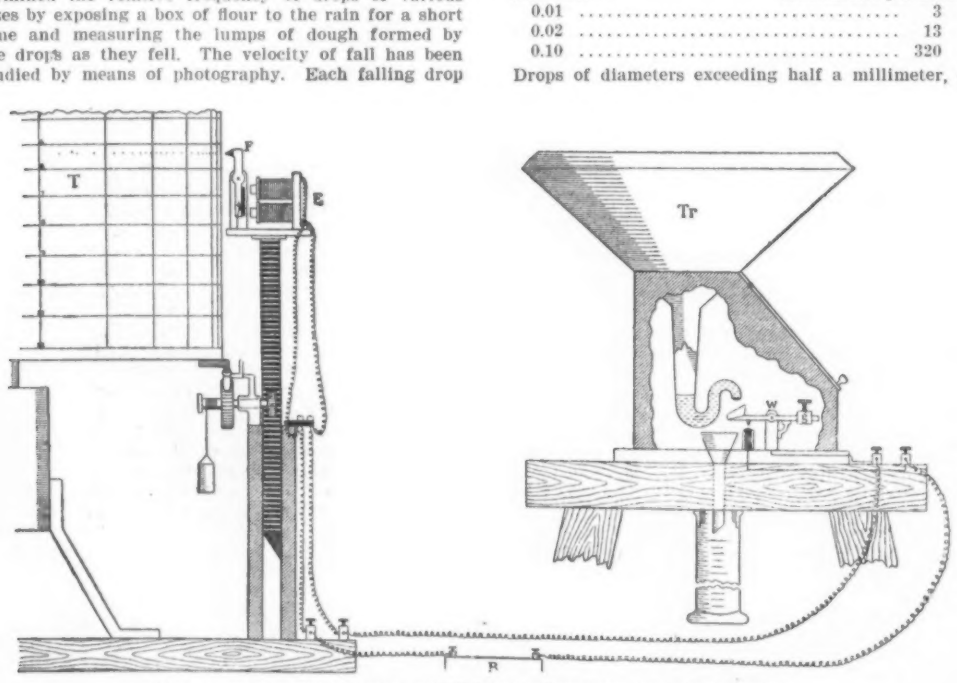


FIG. 1.—GALLENKAMP'S SELF-REGISTERING PLUVIOMETER.

Lenard has studied the number and distribution of raindrops of various sizes by exposing blotting paper to the rain for a short time and dusting the sheet with a soluble pigment, to make the wet spots visible. From such experiments much may be learned concerning upward air currents, as these prevent the fall of drops smaller than a size which depends on the velocity of the current. Lenard divides rains into two kinds, "quiet" and "tumultuous." In the former, drops of all sizes occur, but small drops are most numerous. In the latter, which are accompanied by upward air currents of varying intensity, the sizes of the drops vary accordingly.

The usual methods of pluviometry give little or no information respecting the details of rainfall. The simple rain gage, read once in twenty-four hours, gives the total precipitation during that period but tells nothing about its variations. Somewhat more satisfactory in this respect is the self-registering apparatus which draws, on a rotating cylinder, a line whose varying slope corresponds to the varying speed with which the level rises in the gage, but this instrument is not sufficiently sensitive to record small variations of short period. In brief showers, in which the precipitation may be only a small fraction of an inch and yet may be very irregular, the record of the self-registering instrument is merely a short and nearly straight line which tells nothing. But it is evident to even the unscientific observer that, with rare exceptions, rain falls irregularly, heavy alternating with light rainfall or none, at intervals of a few minutes or even seconds. All ordinary pluviometers, including the self-registering instruments, fail to take account of these variations.

The recording of these details involves the measurement of very small quantities of water. The most obvious method is to count and measure the rain drops, as, indeed, Lenard has done. But it is difficult to do this with accuracy and hardly possible to do it automatically. A simpler plan is to count, instead of the actual raindrops, the drops that fall from the receiving funnel of the gage. It is evident that the frequency of these drops will be proportional to the intensity of the rainfall, and that it is merely necessary to have some means of registering them, automatically and chronometrically.

The apparatus which Gallenkamp has devised for this purpose is shown in the accompanying illustrations. Each drop, as it falls from the receiving funnel, *T r*, closes, by means of the key, *W*, the circuit, *B*, of the electromagnet, *E*, and thus causes the pen, *F*, to make a dot on the rotating cylinder, *T*, which is marked off in hour and minute spaces. The "harder" the rain, the more closely crowded together are the dots on the record for that minute, and the exact chronometric evaluation of the record gives an accurate and detailed history of the shower or the storm. As the size and weight of the drops are constant for each apparatus (except for a small correction depending on their frequency) the amount of rainfall for any given interval can also be easily computed.

As long ago as 1894, in India, Fallenkamp measured heavy showers by a similar method, not using the above described apparatus, however, but timing the drops with a watch. These experiments proved the interesting fact that in such showers the variations in intensity occur with great regularity and represent a periodic wave motion gradually decreasing in amplitude. The typical and almost universal succession of

* Meteorologische Zeitschrift, 1904, p. 249.

phenomena in a shower is the following: It begins with a short and light shower, and this is followed by a longer or shorter cessation of rain, after which comes the first heavy downpour. After this the intensity of precipitation alternately decreases and increases but, on the whole, gradually diminishes until the shower is over.

This discovery of the periodic character of rain furnishes a striking confirmation of the theory enunciated by Helmholtz and other physicists, according to which a shower is the result of a change in an air wave analogous to the combing of breakers on a sea beach. A wave of this sort must traverse an extensive field and produce rainfall of the same character in every part of it. This fact may be demonstrated by the aid of the self-registering apparatus described above. Comparison of the intensity curves obtained at various points should show clearly the path of the air waves, their possible modification by local influences, etc. Pillenkamp has made an attempt in this direction by comparing the records obtained at Nuremberg and at Fuerth, about four miles away, during the violent cloudburst of June 3, 1903. Although there was a difference of an hour between the times of beginning of rain at the two places the curves agree so closely in all their details as to make it very probable that both showers were caused by the same air wave.

The field of observation that awaits exploration by this apparatus is very extensive. The differences, often very great, between rainfall at places at no great distance from each other, the relations between rainfall and electrical discharges, the forms of clouds, etc., and many other things may find explanation when the present method of measuring only the total amount of rainfall shall have been replaced by a method which records the phenomena in detail.

THE RADIATION OF LIGHT BY PLANTS.*

By Prof. Dr. HANS MOLISCH.

SIXTY-TWO years ago, at a session of the twenty-first Congress of German Naturalists and Physicians, in Graz, over which the famous chemist, Justus von Liebig, presided, an Austrian naturalist, J. F. Heller, described the radiation of light by decaying wood, and expressed the opinion that the light emanated, not from the wood itself, but from a fungus by which it was infested. Not long afterward Heller submitted the luminosity of decaying plants and animals to a thorough investigation. He found that the radiation of the flesh of dead marine animals and of various decaying parts of plants represents a biological rather than a purely chemical process, and that it is always due to a fungus. The light proceeds, not from the meat, fish, or wood, but from the fungus which grows upon it and causes its decomposition.

As Heller's investigations fell into complete oblivion and there remained until I recently brought them to light, the priority of this discovery, which unquestionably belongs to Heller, has been erroneously attributed to the distinguished physiologist, E. Pflüger.

The recognition of the biological character of the problem gave a firm basis for further investigation. Soon after Robert Koch had enriched science with his biological methods and pure cultures such cultures were made of various luminous bacteria, to which luminous fungi of higher organization have recently been added. Now it became possible to distinguish the various species, to study conveniently the conditions of radiation and the nature of the light and to attack the problem of luminosity with success.

If we except the luminous peridineæ, which have

TOP, OR REPRODUCTIVE PART, OF AGARICUS MELLEUS.

The mycelium, or vegetative part, which grows under the bark of trees, is luminous, the top is not.

been classed alternately with animals and with plants and which play a prominent part in the beautiful spectacle of the phosphorescence of the ocean, and also except the so-called "flashing" of many flowers—a phenomenon first observed by Linnaeus's daughter and probably of purely physical character and analogous to St. Elmo's fire—we may assert that all luminous plants belong to two classes of fungi, filamentous fungi and bacteria. To prevent misunderstanding I should explain that when I speak of luminous plants I always refer to light produced by the plant itself and not to reflected light, which is known to be the cause of the splendid iridescent colors of many marine algæ, the wonderful emerald green glow of the pro-embryo of *Schistostega osmundacea*, and the sheen, resembling molten gold, of *Chromophyton Rosanoffii*.

Already some thirty species of bacteria and about

PURE CULTURE OF AGARICUS MELLEUS.

This is photographed by reflected light. The mycelium, or base, alone is self-luminous.

half as many of other fungi are recognized as luminous.

This number is exceedingly small in comparison with the whole number of known species of plants. Nevertheless, as some of the luminous fungi are among the commonest of plants, we are often surrounded by luminous objects in nature, and even in our houses, as the following examples will show.

Until recently luminous meat was regarded as a rare and remarkable curiosity and its occurrence was attributed to unknown conditions, seldom to be met with. When I undertook to investigate the subject I had no material and, although I communicated with a number of persons and establishments likely to come into possession of luminous meat, I could not, in two years, obtain a single specimen. I was about to abandon the undertaking when it occurred to me to examine the meat bought for household use. To my astonishment I found that this meat, after being kept from one to three days in a cool room, often began to radiate light spontaneously. In the course of my investigation I learned that the radiation was most likely to occur in meat about half immersed in a 3 per cent solution of salt. Of the specimens examined in the course of three months, not less than 87 per cent were found to be luminous, that is, 89 per cent of the specimens of beef and 65 per cent of the specimens of horseflesh. The source of the light was proved, by the method of pure culture, to be, in every case, the same intensely luminous *Bacterium phosphoreum (Cohn) Molisch*. As I have now continued my investigations for several years, not only in Prague, but also in other cities, and have always obtained substantially the same results, the spontaneous luminescence of meat must be regarded as a very common phenomenon.

The cause of the radiation, the *Bacterium phosphoreum*, must therefore be one of the commonest of bacteria. It occurs on meat in the cold storage room, the slaughter house, and the market, and even infests the kitchen. Such an assumption is necessary to account for the astonishingly large proportion of specimens of meat that radiate light spontaneously.

In the last few years I have met with another phenomenon of luminescence which, though of very common occurrence, has been entirely ignored. I mean the radiation of light by decaying leaves. In my nocturnal strolls in the tropics, especially in Java, I often found dead leaves of *Bambusa*, *Nephelium*, *Aglaia*, and other plants, which glowed in the dark. Since my return to Europe I have followed up the subject and discovered that luminous dead oak and beech leaves are very abundant in central Europe. The leaves must be in a moderately damp condition and in a particular stage of decomposition. Especially fine luminescence is exhibited by leaves which have acquired, in the course of decay, a pale yellow tint, with or without brown markings. Usually they glow in spots, but sometimes throughout their whole extent, with a soft, white, steady light. Here, also, the source of the light is not the decaying substance of the leaf, but the fungus that infests it.

It appears from my observations that a considerable proportion of fallen leaves in oak and beech forests is luminous in summer, and that the ground in the forest is everywhere illuminated by the light of decaying leaves which, though faint, is clearly discernible at night. Unfortunately, I have not yet succeeded in identifying the fungus which causes the luminescence.

On the other hand, I have successfully applied the method of pure cultures to the fungi which cause the luminescence of wood, and have identified them, in most cases, as *Agaricus melleus* and *Mycelium X*. At the same time I have learned that certain cryptogams, including *Xylaria hypoxylon* and *Trametes pini*, must be stricken from the list of photomycetes, or luminous fungi, in which they have generally been included.

Bacterium phosphoreum (Cohn) Molisch and *Mycelium X* (provisionally so named because it cannot be induced to reproduce itself even after several years' culture) are particularly favorable objects for study and experiment, because of the comparatively great intensity of their radiation and its very long duration.

Beijerinck has made a very thorough and valuable investigation of the relations between the luminosity and the nutrition and growth of luminous bacteria. He was the first to show how these bacteria may be employed for the detection of extremely small quantities of oxygen and of certain enzymes. These physiological methods rival, and even surpass in sensitiveness, the best physical and chemical methods of analysis and prove that the living organism is able to render, as an instrument of research, inestimable services to science.

In order to make clear the nature of the radiation, it is necessary to presume that the presence of free oxygen is indispensable. The light is due to oxidation. In popular lectures I demonstrate this fact in the following way:

A glass tube from three to five feet long and one-third of an inch in diameter, closed at one end, is filled to within one-half inch, or less, of the top with bouillon made strongly luminous by *Bacterium phosphoreum* or *Pseudomonas lucifera*. After the tube has stood about fifteen minutes the light vanishes from lack of oxygen, except at the extreme top, where the bacteria are in contact with the air. If the tube is then closed with the thumb and inverted the rising bubble of air makes the whole tube luminous again.

In the dark, the appearance is that of an ascending rocket. In another quarter of an hour or less the light vanishes again and may be reproduced as before.

The nature of the light has recently been studied by E. Pflüger, Radziszewsky, Dubois, F. Ludwig, Katz, Tollhausen, Lehmann, Beijerinck, McKenney, Nadson, and others, with discordant results. As our knowledge of the subject increases, however, increased support is won for the view that there is produced within the cell a hypothetical substance, photogen, which becomes luminous in presence of free oxygen. This theory is confirmed by the discovery of Radziszewsky that many organic substances become luminous in presence of alkalies and free oxygen. Furthermore, there are certain observed facts which, in my opinion, compel us to assume the existence of a photogen. Characters written with the luminous matter of *Luciola italica* may be brought to renewed luminescence by moistening. The luminous organs of the glow-worm (*Lampyris noctiluca*), when thoroughly dried and kept *in vacuo* do not emit light; but if (even after a year, according to Bongardt) they are exposed to the air and moistened with a drop of distilled water, the light reappears. Filter paper impregnated with a secretion of certain millipedes may be made luminous by wetting after being kept two months. In these cases we can not speak of living cells or cell constituents, for the luminous organ of

DECAYING BEECH LEAF.

The light-colored (pale yellow) part is luminous.

an insect which has been kept desiccated *in vacuo* for a year cannot be regarded as living. We have to do, not with a vital, but with a purely chemical process, and with a substance that becomes luminous in presence of water and free oxygen.

In the luminous plant there is no luminous secretion (as has been erroneously assumed), for the light is developed only in the interior of the cell. It has also been observed, hitherto, only in the living cell, and to this extent it may be regarded as a true vital light. But the alcoholic fermentation was, until recently, believed to be inseparably connected with the living yeast cell, and we now know, thanks to Buchner's discovery, one of the most brilliant in the history of biochemistry, that fermentation is due solely to a definite, lifeless, chemical substance, the ferment

* An address delivered before the Congress of German Naturalists and Physicians, at Meran, September 24–30, 1905, and translated for the SCIENTIFIC AMERICAN SUPPLEMENT. Comprehensive data and a bibliography of the subject may be found in Dr. Molisch's book "Leuchtende Pflanzen. (G. Fischer, Jena, 1904.)

zymase, which causes fermentation even when isolated. This suggests an analogy for photogen. The fact that no such luminous substance has yet been isolated is due in all probability to the very small quantity in which it exists, its great instability and its immediate change on the death of the cell. It is not yet possible to describe the nature of photogen or to say whether or not its light is produced by a fermentative process. Further study is needed to decide these questions. To prove, directly or indirectly, the existence of photogen, to isolate it, if possible, and bring it to luminous emission outside of the cell appear to me as very fascinating and, in view of other biochemical discoveries, not altogether hopeless objects of endeavor.

Everyone who has beheld swarms of fireflies darting through the blackness of night like living stars or has regarded, with well rested eyes, brightly luminous cultures of bacteria and higher fungi, must have been strongly impressed by the peculiar character of this "living light." It is therefore easy to understand that at an epoch when physicists are surprising us with new and unsuspected radiations, great attention should be directed to the nature of these radiations from living creatures and to their physical, chemical, and physiological effects.

In the first place, I wish to point out a remarkable difference between the character of the light emitted by animals and plants. If we disregard the peridineæ, which are possibly to be classed as animals, and confine our attention to the fungi, we may assert that the light of plants is always long continued, for the bacteria and higher fungi shine for days, weeks, months, and with abundant nutriment and other favoring conditions even for years, continuously, day and night, while animals, with few exceptions, radiate only during relatively short periods, usually of a few seconds or minutes, and usually in response to an external stimulus, so that the light appears as a flash or spark.

The light emitted by fungi is white, green, or blue-green in tint and, contrary to earlier assertions, it is never wavering, like that of phosphorus, but always steady and uniform, whether observed with the naked eye or with microscope. Its apparent intensity, as a rule, is slight, though the light of some bacteria is discernible, even with the unrested eye, in the darkest corner of a room in broad daylight. An excellent object in this respect is the *Bacterium phosphoreum (Cohn) Molisch*, the luminous bacterium of butcher's meat, and a still better one is *Pseudomonas lucifera Molisch*, which I discovered in sea fish two years ago, and which surpasses all other known luminous bacteria in intensity of radiation.

The spectra of fungi are continuous, without dark lines, and attain their maximum brightness in the green. The spectra of the strongly luminous bacteria mentioned above extend further toward the violet than those of the higher fungi. In the spectrum of *Pseudomonas lucifera Molisch* I could distinguish green, blue, and violet. This is the first authenticated case in which colors have actually been seen in the spectrum of the light radiated by a plant.

The composition of the fungus light suggests the possibility of photographing with it, and this has actually been done by Von Haren Noman, Forster, Barnard, B. Fischer, and, in particular, R. Dubois. With the strongly luminous bacteria at my disposal colonies can be clearly photographed by their own light with an exposure of five minutes and good pictures of such objects as statuettes, thermometers, and print can be obtained by the use of bacterial lamps. In the latter case an exposure of several hours is required for sharp definition. On the other hand, an exposure of one second is sufficient to give a visible impression of a linear luminous culture laid directly on the plate. All pictures yet produced have been made by the light of colonies or extended cultures; but, in view of the almost infinite sensitiveness of the photographic plate, it seems to me that we may hope, some day, to photograph a *single* bacterial cell by its own light, as we have succeeded in photographing stars invisible to the naked eye.

The discovery of the Roentgen and Becquerel rays and the radiations of radioactive substances justified the suspicion that rays of a peculiar kind might be present in the light of bacteria, but Dubois's assertion that bacterial light penetrates such opaque bodies as wood and cardboard is based on self-deception, induced by the direct action of the wood and cardboard on the protographing plate. I can explain in the same manner the remarkable and puzzling discoveries of the Japanese investigator Muraoka, in regard to the light of the firefly. The light of fungi and of fireflies acts like ordinary daylight on the photographic plate and cannot traverse opaque bodies.

The physiological effects of bacterial light on plants are not without interest. The heliotropic sensibility, or the tendency to grow toward the light, of the seedlings of certain plants sprouted in darkness, has been shown by Wiesner to be astonishingly great. The plant detects, better than our eyes, very slight differences in brightness, and may be regarded as an excellent physiological photometer. This extraordinary sensitiveness to light induced me to test experimentally the heliotropic power of bacterial light, which I found able to produce positive heliotropism in seedlings of lentils, peas, and vetches, and in the fungi *Phycomyces* and *Xylaria hypoxylon*. It is a wonderful thing to see one plant influencing the movements of another, the bacteria compelling, by the emission of radiant energy in the form of light, the stalk of a plant to grow almost directly toward the source of light. On the other hand, the bacterial light, probably because of its faintness, does not appear able to induce the formation of chlorophyl.

We now come to the question, whether so striking a phenomenon as the development of light in a plant is of any recognizable advantage to the plant. All zoologists appear to agree that the light produced by animals is beneficial to them, for when we consider the lightning-like, explosive emission of light, the sudden explosion of a luminous secretion and the marvelous construction of the luminous organs of animals living in the black depths of the sea, we cannot doubt that these appliances exist for the service of the organism and that many animals derive definite benefit from their power of radiating light, either because they thus attract or frighten each other or are aided in catching their prey by the illumination of their environment.

In the case of plants, the question is far more difficult to answer. The opinion has been expressed that the luminosity is an aid to their dissemination. The light emitted by bacteria living on stranded and decomposed marine animals is supposed to attract various beasts of prey which carry off the flesh and thus scatter the bacteria. I agree with Beijerinck, however, in maintaining that this view is untenable, because ocean currents, waves, and shifting sands amply suffice to account for the dissemination of the bacteria.

The case of the luminous mushroom-shaped fungi is rather more doubtful. The eminent biologist Kerner has expressed the opinion that the light of these plants attracts the flies and beetles that lay eggs in their mycelia and spore-cases and incidentally carry away and disseminate the spores of the fungi. This view is attractive at first glance, but closer examination discloses certain insuperable objections. For example, it is difficult to understand why, in *Agaricus melleus*, the receptacle, which bears the spores and is easily accessible to insects, is not luminous, while the mycelium, which grows in the wood of the host, under the bark, and usually contains no spores, is luminous. Even if the light of the mycelium did attract insects or their larvæ, the result could only be injurious to the fungus, which would be destroyed, and not disseminated. Its luminosity would therefore prove its ruin. If the function of the light of plants is to attract insects at night, it is not easy to understand why it is emitted also in the daytime, when it is invisible. The case of luminous plants is essentially different from that of luminous animals and therefore I prefer to refrain from bold speculations and to admit that at present it is impossible to give any plausible ecological explanation of the luminescence of fungi, probably because it is merely a necessary result of the metabolism of these plants.

Finally, when we regard the problem from the standpoint of energetics, it appears that radiant energy in the form of light may be developed in plants, in addition to chemical and electrical energy and heat. This is a wonderful fact! In its microscopically small laboratories, the chlorophyl grains, the green cell receives the radiant energy of the sun and transforms it into chemical energy, by building up, out of atmospheric carbon dioxide, the organized tissue which is a storehouse of energy. These organic substances serve as food for luminous animals and luminous plants and thereby reproduce heat and light. Within vegetable life, therefore, there is a complete cycle from light to light! In every case—the radiation of the glow worm, the sudden flash of *Noctiluca* or the *Peridineæ* when lashed by the waves or stirred by a ship's keel, the illumination of the sea bottom by luminous crustacea, the soft radiance of a fungus in the forest or of bacteria in decaying flesh—the light emitted by living organisms is essentially nothing but the radiant energy of the sun, received and transformed by plants.

It is sunlight born anew.

TURPENTINE STAINS AND WATER STAINS.

THE purpose of this article is to set forth the advantages and disadvantages of these two kinds of stain, and to correct the idea, prevalent among painters and cabinet makers, that water stains are of little value or even impracticable for staining wood.

Turpentine stains are chiefly solutions of oil-soluble coal-tar dyes in turpentine oil, with small quantities of wax also in solution; they do not roughen the wood, making a final polishing unnecessary, a great advantage, and they enter the wood slowly, a further advantage, whereby a more even stain, especially on large surfaces, is secured. The disadvantages of turpentine stains are the lack of permanence of the coloring, when exposed to light and air, and their high price, consequent upon the present increased price of turpentine oil. The lack of permanence is a great fault, and cannot be remedied, since there are not at present upon the market any coal-tar dyes, soluble in turpentine oil, which, in point of fastness to light, meet the requirements for staining wood, itself so durable. Furthermore, the price of turpentine oil will not fall, since the demand for it is increasing constantly, and the supply from America, the chief producer, is becoming limited.

Water stains are solutions of chemicals, dye extracts, astringent substances, and coal-tar dyes in water. They roughen the wood, a disadvantage, however, which can be remedied to a large extent by previous treatment of the wood, as follows: It is moistened with a wet sponge, allowed to dry, and then rubbed with sandpaper, or made smooth by other agencies. This almost entirely prevents roughening of the surface by the stain. Another disadvantage of these stains is that they are very rapidly absorbed by the wood, which makes an even staining of large surfaces difficult. For this too there is a remedy. The surface of the wood is rubbed all over evenly with raw linseed oil, applied with a woolen cloth, allowed to dry, and then thoroughly smoothed with sandpaper. The water stain, applied with a sponge, now spreads evenly, and is but slightly absorbed by the wood.

Some of the water stains upon the market leave much to be desired in point of fastness to light; but there is a small number of dyes and chemicals, readily soluble in water and very fast, and these are the colors to be chosen. Among these may be named the long-known Cassel brown and nut brown, in granules; catechine is recommended for brown shades, with tannin or pyrogallic acid and green vitriol for gray; for bright-colored stains the tar-dyes azine green, croceine scarlet, Parisian red, tartrazine, water-soluble nigrosine, walnut, and oak brown are very suitable. With proper mixing of these dyes, all colors except blue and violet can be produced, and prove, according to W. Zimmerman's experiments, very fast to light and air, and superior to turpentine stains. Only the blue and violet dyes, methyl blue, naphthol blue, and pure violet, do not come up to the standard, and require a second staining with tannin.

A very simple method of preparing water stains is as follows: Solutions are made of the dyes most used, by dissolving 500 grammes of the dye in ten liters of hot water, and these are kept in bottles or casks. Any desired stain can be prepared by mixing proper quantities of the solutions, which can be diluted with water to make lighter stains, and quickly made ready for use.

There is a third kind of wood stain, viz., spirit stain, but it is not greatly in favor. It contains the same color constituents as the turpentine stains, and shares their lack of fastness to light. Spirit stains have no advantages over turpentine stains, and should be entirely excluded from real wood staining, and used only for coloring spirit varnishes and polishes.

Zimmerman recommends to the consumers of wood stains to make experiments in regard to the fastness of the stains most used, by means of exposing stained surfaces to the light of summer, under burnished glass, and comparing the results with those of similar exposure of stains known to be fast. Institutions for teaching the industrial arts should test all the new chemicals and dyes which appear, for their value as wood stains, and communicate the results to persons engaged in such work. The old formulas for stains should also be revised.—Translated from the Muler Zeitung.

SENSE OF HEARING IN FISH.

READERS of Brehm's "Tierleben" (Animal Life) will recall a statement to the effect that the carp inhabiting a pond in a certain Continental town are accustomed to come up to the landing steps at the sound of a bell to be fed. And from this and other circumstances it has been commonly held, at least up to the middle of the last century, that fishes possess the sense of hearing.

In the year 1851 were discovered, however, the so-called organs of Corti in the internal ear of mammals, which there is good reason to believe alone receive and transmit to the brain the vibrations giving rise to the sense of hearing. Now, these organs of Corti, together with the bony "labyrinth" of the internal ear in which they are contained, are absent in fishes alone among the whole group of vertebrates, and it accordingly seems highly probable that these creatures lack the power of hearing, more especially since there seems reason to believe that the aforesaid organs of Corti are absent in such few members of the other classes of vertebrates as are deaf. If this be so, it follows, of course, that the so-called otoliths (the familiar solid white bones in the head of a cod, for instance) in the ears of fishes have nothing to do with the sound of hearing.

The whole question has recently been discussed in an exceedingly interesting manner by Prof. O. Korner, director of the ear hospital at Rostock. The learned professor says that nature is never wasteful, and since fishes possess keen power of sight, smell and touch (in the so-called lateral line on the side of the body) it is improbable that they are also provided with the sense of hearing. He incidentally cites as a proof of this the presence of numbers of sharks at the battle of Aboukir Bay and other naval battles, pointing out that if those fishes had heard the roar of the cannon they would scarcely have swum about in their usual unconcerned manner, intent only on business.

Another argument urged is that the sense of hearing would be useless to fishes, since the enemies by which they are attacked rush silently upon them in the waters or swoop down upon them from above. The vibrations caused by the breaking of the waves on the beach are probably communicated by the lateral line system, so that fishes are warned in this manner of the proximity of land.

Brehm's anecdote of the carp coming to be fed does not by any means imply that these fishes hear the sound of the bell; and it is much more likely they feel the vibrations communicated to the water by the fact of the person coming up to the landing steps.

Moreover, according to the German professor, it appears as the result of direct experiment that while fish are able to take cognizance of numerous rapid vibrations in water, such as those communicated by

an electric bell, they take no notice whatever of loud single explosions under water, such as those made by dynamite. This strongly points to the conclusion that they receive impressions of the former type of vibration by means of their sense of touch or feeling, but that they have no perception of either kind of vibration by means of hearing.—London Field.

SCIENCE NOTES.

Stephen **Schultz** says: "At Beitdjin, a village near Ptolemais, we took our supper under a vine, the stem of which was nearly a foot and a half in diameter, the height about 30 feet, and it covered with its branches a hut more than 50 feet long and broad."

There has been a veritable flood of malarial literature of recent years, including an annual volume of "Atti della Società per gli Studi della Malaria," the series commencing in 1900, which has come to us from Italy. Mosquitoes have received an immense amount of attention, after being much neglected in the past. The number of genera and species and their classification have become subjects to bewilder all but specialists.

A cytological and micro-chemical study of numerous plants in various conditions of culture is needed. Loew has instituted some good work in this direction. He attempted a careful microscopic study of *Spirogyra* under the conditions indicated. Although well rewarded, he has not followed up the result. The problem is, nevertheless, again under serious investigation, and when much time and thought shall have been devoted to it, with the utilization of the best cytological methods available, important results may be anticipated. The possibilities of the future are particularly dependent upon this, that investigation must be made of all microscopic changes as well as of all demonstrable microscopic changes.

We are well assured now that the earth as a part of the solar system has had a long history. That all these bodies have reached their present conditions and relations by a process of growth taking millions of years. The same factors that have been active in the past are still operative, producing changes in magnitude, in distances, in temperature and the like. The moon, once a corporate part of the earth, has left it through tidal action and will move still farther away for something like fifty millions of years, after which it will return. The sun is a mass of gas, which by its contraction through gravitation has become exceedingly hot, and is radiating its energy away at a definite and known rate. As it is limited in size and amount of material, one may without difficulty calculate that the supply of heat from it will last about ten millions of years. It will cease to shine and become cold unless something like a catastrophe shall re-endow it with high temperature and larger volume, when it may repeat the history of these millions of years past. The same conditions of contraction and rise in temperature are observable in thousands of the heavenly bodies, and in all stages from thin gaseous masses to cold non-luminous solid bodies. Now that we know so much of the past history of the solar system, and in addition that our nearest neighbor is more than 200,000 times the distance to the sun, also that the whole system is itself moving in space at the rate of about 400 millions of miles a year in the direction of the star Vega, we yet need to know whether this motion is a drift or part of an orbit. At present no one knows. The direction and rates of motion of a number of stars have been very well determined, but such measures are not numerous enough to enable us to say whether there is more order in the movements of stars than there is among the molecules of a gas, where molecular collisions are constantly taking place. Such phenomena as that of the new star which suddenly blazed out in Perseus are now explained only by assuming stellar collisions wherein the masses are so large and have such velocity that impact at once reduces them to incandescent gas. This means the possibility of such disaster to the solar system, but it is a present comfort to know that if we were to collide with our nearest neighbor at present rate, 12 miles a second, it will take nearly 50,000 years to reach it.

The fine art of modern agriculture is as much beyond the uneducated and untrained man as the art of sculpture is beyond the ordinary quarryman. The poor of the cities can not be sent to the country, and there made into farmers, as easily as some superficial observers may think. The young man who would be a farmer or horticulturist must either be trained by some experienced member of the profession who has kept abreast of the times and has made a success of farming or horticulture, or he must go to an agricultural school, where agricultural training is made a business. A combination of both is still better. If a correct educational system has been followed in the common schools under competent teachers, the young agriculturist will have when he comes to the agricultural college a practical knowledge of farm operations and a good general elementary education, including a training in the elements of natural history, before described as desirable for the young physiologist. It may be possible to obtain this training from the primary graded schools of our towns and cities. It is, however, much more likely to be secured through the newer system of consolidated rural schools now being adopted in our most progressive agricultural States. This rural-school system starts with a primary school and leads up to the agricultural high school and college of agriculture, and has as its aim from bottom to top the training of agriculturists. The system meets a recognized economic and educational need and is sure to take a place co-ordinate with the older systems.

ELECTRICAL NOTES.

The Danish Biological Station, according to a notice in Elektroteknisk Tidsskrift, Copenhagen, is making experiments with a view to illuminate the bottom of Little Belt with electric incandescent lamps, in order to prevent the eels from migrating out to the large seas, it having been shown that these fish, being shy in regard to light, do not perform any migration during moonlit nights. It is interesting to note how many different branches of industry are now being pervaded by electricity.

Moissan's classic researches show us that a large number of elements unite with carbon to form carbides, many of which were not known before the day of the electric furnace. Based upon this fact, though resulting from the independent discovery of the American inventor, Willson, the calcium carbide industry has been developed. This material was unknown a few years ago, but to-day thousands of tons are being produced annually. The reaction of this carbide with water forms that hydrocarbon, acetylene, which, although now finding its chief use as an illuminant, is capable of being transformed into other hydrocarbons. Manganese carbide reacts with water to form hydrogen and methane, thorium carbide gives ethylene, and cerium and uranium carbides yield liquid and solid hydrocarbons as well as gaseous ones. Although the hydrocarbons other than acetylene have not been produced commercially, scientifically it is possible to produce petroleum and other like compounds. Such discoveries as these point to the great and significant fact that the whole field of organic chemistry offers itself as an incentive in the exploitation of the electric furnace.

On the tramway lines in Germany the overhead trolley wire is used almost entirely, and the exclusive use of the storage battery system is only found on a three-mile line at Bremerhaven. We find a combined overhead and underground conduit system in some of the large cities, for instance at Dresden, Berlin, and Düsseldorf. The city of Königsberg has a two-wire overhead trolley line. The use of storage batteries is disappearing in the case of tramway lines, but it is kept up on the railroad lines as, for instance, the local railroad from Ludwigshafen to Mannheim, on ten sections of the Palatinate railroad, and on the Augsburg-Gessertshausen and two other railroad lines. The third-rail system is used on the surface and underground road in Berlin, on the Berlin-Lichterfeld road, and on the Barmen-Elberfeld suspended road. The use of the alternating current on the single-phase system is a recent experiment which proved very successful on the local railroad from Oberammergau to Murnau. It is proposed to use the same system on a larger scale on the new Hamburg-Altona interurban line. The new system of electric automobiles which run over the public roads by means of hanging a trolley is coming into use, and already there are six lines, counting fifteen miles in all, which are using it.

The Oerlikon Company, the well-known Swiss electric house, and the Siemens-Schuckert Company, of Berlin, are said to have made an agreement by which these two firms are to co-operate in drawing up plans and preparing the preliminary work in order to introduce the electric system upon the Swiss government railroads, without interrupting the traffic upon these lines. The Oerlikon Company has already carried out a series of experiments with the single-phase system of motors for locomotives. The Berlin firm will bring into the combination the results of the tests which were made on the Marienfeld-Zossen experimental high-speed electric road, which will be of great help in preparing the new projects. In Sweden the question of electric trains for the government railways is even further advanced, and an electric locomotive has now been built for the purpose of making the tests. Some new features are to be met with in this case, not only in the alternating single phase current to be used, but the tension is unusually high. This is 18,000 volts on the trolley wire, but different lower tensions will also be experimented with, down to 3,000 volts, in order to find out which is the best for use on the railroad.

In the course of his researches on the external conductivity of silver wires immersed with water, E. Rogovsky, as stated in a memoir recently presented to the French Academy of Sciences, observed the remarkable fact that the resistance of wires dipped in water decreased at the beginning when the electrical current traversing these wires augmented, in order afterward to increase; the temperature of the wire accordingly fell instead of rising between the given limits of current intensity. This variation in resistance, which at first sight would seem striking, is accounted for simply by the fact that the temperature of the wires depends not only on the amount of heat evolved by the current, but as well on that lost by the lateral surfaces of the wires, i. e., on the external conductivity the wires possess in water. The speed of the water current in which the wires are immersed exceeding the critical speed of Mr. O. Reynolds, a stagnating layer of appreciable dimensions could not be formed, being carried along by the whirling water-current. It, however, seems likely that a wire which is not traversed by electrical current or else traversed by very low currents, is surrounded by an exceedingly thin (molecular) water-layer clinging to the silver and sliding alongside the wire according to experiments by Von Helmholtz and Piotrowski. Owing to the heating effect produced by very small currents before the heat given off by them is sufficient to carry away the adhering water layer, the resistance of the wires immersed in the liquids, as determined with small currents, will correspond with a temperature superior to that of the liquids. In order to obtain the exact values of the resistance in the wires at the temperature of the liquid they are immersed in, an extrapolation should therefore be made from a series of observations made at different current densities.

ENGINEERING NOTES.

A good locomotive boiler water is one that is free from all impurities, except a small proportion of soluble noncorrosive salts, giving a total of from three to six grains of solid matter per United States gallon. The waters most injurious to locomotive boilers are, in order named: Those containing acid, corrosive solids and salts, alkali, free carbonic gas with free oxygen, high scale-forming ingredients and water contaminated by sewerage and organic matter, although this relation may change as the amount of the different impurities varies.

William O. Webber has designed an absolutely balanced compound centrifugal pump, by causing the impellers to be placed back to back, but not in pairs serially disposed; and in producing results, from the method in which he sequentially connects the different impellers, so that both the sum and difference of the suction and discharge pressures of all the impellers in any compound centrifugal pump equalize and balance each other.

The "hit-and-miss" system of gas-engine regulation is defective in the following particulars: (1) After a stroke with no charge, the following explosion is more powerful in certain cases and weaker in others, according to the form and the arrangement of the explosion chamber and its ports. (2) Violent explosions are often produced, the consequences of which are the more injurious to the life of the working parts as the engines are larger and consequently oppose the inertia of heavier masses to movement. (3) The intermittence of the explosions produces cyclic variations or irregularities in the revolutions of the flywheel regarded individually, and that these irregularities are incompatible with the working conditions of dynamos for lighting, etc. (4) In order to overcome these difficulties it is necessary to use extra heavy flywheels, which constitute an additional load on the engine and cause a reduction of mechanical efficiency.

The question is sometimes asked whether it pays to reduce the pressure when the load is light. It hardly pays to reduce the pressure on the boiler, except in very extreme cases, but if it can be done by throttling before the steam reached the cylinder of the engine, it would be an advantage, because this retains the heat units due to the higher pressure in the steam and the throttling has a slight superheating effect. As a matter of fact, tests made by Willans & Robinson, of England, go to show that for light loads and high pressure a throttling engine may do even better than automatic cut-off. The ideal arrangement is to throttle the steam for light loads up to say, near quarter cut-off, and after that, for heavier loads, allow the variable cut-off to come into play. This practice has been carried into effect by the design of Mr. E. J. Armstrong, in which he arranges the shaft governor so that there is negative lead up to nearly one-quarter cut-off, after which the lead becomes positive, and this has the effect of throttling the steam for the earlier loads and undoubtedly gives better economy, in addition to making the engine run more quietly.

By the end of 1904 the Prussian State Railways had put into service 127 engines using superheated steam, all except the original two and the last one having the smoke-box type of superheater. Other European roads have, since 1902, also built engines with the Schmidt designs of superheaters, the smoke-box and smoke-tube types being used about equally and in all about 170 of these engines are in service. Other engines have also been equipped with the Pielock, a rather different type of superheater to the Schmidt, which was developed in 1902, and which has now been applied to about thirty locomotives, thirteen of these being on the Prussian State Railways, so that, in all fully 200 engines in Germany are now running with superheated steam. In America it was introduced by Mr. Roger Atkinson, then mechanical superintendent of the Canadian Pacific Railway, who, in 1901, applied a Schmidt smoke-box superheater to an 18x24-inch ten-wheel simple freight engine with 62-inch wheels. This engine proved exceedingly satisfactory, and was followed two years later by two ten-wheel compound freight engines, which were equipped with the Schmidt smoke-tube arrangement. All these engines showed a substantial economy over similar engines of the ordinary type, and, in 1904, forty-one simple consolidation engines were built, of which twenty were equipped with the Schmidt and twenty-one with the Schenectady superheater. During that year one of the latter type was also applied to an Atlantic type simple engine on the New York Central and to a ten-wheel passenger engine on the Canadian Pacific. During the present year, 1905, the Canadian Pacific Railway is building fifty-five simple ten-wheel freight engines and six Pacific type passenger engines, which will be equipped partly with the Schmidt and partly with modified Schenectady and other types of smoke-tube superheaters, and a number of other roads are also experimenting with this system, which is therefore fairly well started, experimentally, and is now in sufficiently extensive use to develop its troubles in regular service, and emerge from the nursing stage, which always engenders the suspicion that particular attention to one engine's performance may obtain results that would not be realized from a number.

TRADE NOTES AND FORMULÆ.

Simple Production of a Warming Bottle.—According to Weils, a cheap and useful warming flask can be prepared as follows: Mix 1 part of sodium acetate with 9 parts of sodium hypo-sulphite, filling a clay flask about three-quarters full; next it is tightly closed with a cork and laid into hot water or the oven, so as to cause the contents to melt. This hot-water bottle will give off heat for hours up to half a day and becomes hot again when it is vigorously shaken from time to time.—Leipziger Populäre Zeitschrift für Homöopathie.

Antiseptic of Formol Base.—Formic aldehyde is, as known, employed frequently as an antiseptic and disinfectant, but the commercial form in which it is used (solution in water, 40 per cent) is an obstacle to its general employment. A solid product is obtained by the Société des Produits Chimiques, which is said to be perfectly soluble in water and to furnish formic aldehyde of any desired strength, by mingling trioxymethylene with sulphite of soda. The trioxymethylene, which is insoluble in water, is soluble in solutions of sulphite of soda, and yields liquors which have all the antiseptic properties of formol. Very small quantities of the sulphite will dissolve the trioxymethylene, a larger quantity increasing its solubility. The mixture may be used alone or in combination with other antiseptics. It may also be employed with coloring matters, perfumes, and other accessory products.

How to Restore Cracked Bells.—A process for the restoration of cracked bells without remelting was explained by Prof. Wolff at the Exposition on the Care of Monuments recently held in the court of the Old Castle at Strasburg. According to Prof. Wolff's lecture the bell is first carefully cleaned so as to lay the metal completely bare; then the crack is widened by drillings, and the bell is buried with the opening up; it is now brought to a red-heat, but the heat of the bell should always be a few hundred degrees C. below that of the separately prepared bell metal. The latter is finally poured in and will combine so perfectly with the heated bell itself that upon proper cleansing the original tone is re-obtained most accurately. The process is due to a bell-founder at Montargis near Paris, and has in Germany only been used a few times in Alsace, but always with perfect success. The lecture was elucidated by very fine pictures taken during the various stages of the process, which contributed greatly toward a clear understanding of the method.

Galvanizing of Wires.—A new process to provide wires with a metallic coating has been brought out by Rodman. Large quantities of such wire being needed in the electrical industry, this process, if found satisfactory, will prove of great value in the manufacture of cables and bright wire. According to this process a certain quantity of that metal with which the copper or iron wire is to be coated is poured in a molten state into a metallic receptacle which is connected with a negative pole of a source of direct current, a solution of an alkaline hydroxide being poured in subsequently. Into this solution a metal plate is immersed, which is connected with the positive pole. Carbonate of potash or soda is added and dissolves quickly in the molten mass after diffusion has taken place. The diffusion is facilitated by the lively motion of the electric bath, which is caused by the copper or iron wire running with constant speed over rollers in such a manner that the wire enters the bath from above, crossing the layer of the dissolved alkaline hydroxide and only entering when perfectly cleaned the molten metal, which may be tin, zinc, or lead. By reason of the strong action of the alkaline compounds all oxides are removed from the wire and the metallic coating is evenly distributed, which adheres well to the surface without a previous careful cleansing being necessary.—Der Elektrotechniker.

Ebony Stain.—Water 27 kilos, ground blood shellac 2.7 kilos, ground borax 1.55 kilo, water-soluble tar-dyestuff 0.45 kilo.

Walnut Stain.—Water 22.5 kilos, ground garnet shellac 2.25 kilos, ground borax 1.13 kilos, water-soluble tar-dyestuff (walnut color) 0.466 kilo.

Oak Stain.—Water 27 kilos, ground orange shellac 2.7 kilos, ground borax 1.35 kilos, water-soluble tar-dyestuff (oak shade) 0.47 kilo.

Pine Wood Stain.—Water 36.5 kilos, ground bleached shellac 3.65 kilos, ground borax 1.80 kilos, water-soluble tar-dyestuff (brown pine wood color) 0.372 kilo.

Satin Wood Stain.—Water 27.5 kilos, ground bleached shellac 2.75 kilos, ground borax 1.38 kilos, water-soluble tar-dyestuff (satin yellow) 0.465 kilo.

Mahogany Stain.—Water 27.5 kilos, ground orange shellac 2.75 kilos, ground borax 1.38 kilos, water-soluble tar-dyestuff (mahogany red) 0.560 kilo.

Green Stain.—Water 27.5 kilos, ground garnet shellac 2.75 kilos, ground borax 1.38 kilos, water-soluble green tar-dyestuff 0.37 kilo.

Rosewood Stain.—Water 22.5 kilos, ground garnet shellac 2.35 kilos, ground borax 1.13 kilos, water-soluble tar-dyestuff (rosewood shade) 0.67 kilo.

Poplar Stain.—Water 22.5 kilos, ground bleached shellac 2.25 kilos, ground borax 1.13 kilos, water-soluble tar-dyestuff (poplar shade) 0.418 kilo.

Blue Stain.—Water 27.5 kilos, strong vinegar 0.9 kilo, ground orange shellac 3.6 kilos, ground borax 1.8 kilo, water-soluble tar-dyestuff 0.39 kilo.

For the last-named stain the borax-shellac solution is prepared first, then the solution of the tar-dye in the vinegar; the latter is poured into the former and everything mixed well.

English tar-dye factories furnish the water-soluble tar-dyestuffs required for these stains.—Oesterreichische Farben und Lack Zeitung.

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